FORESTRY

THE JOURNAL OF THE SOCIETY OF FORESTERS OF GREAT BRITAIN

Edited by C. W. SCOTT

VOLUME XXI, No. I

1947

Published by the

OXFORD UNIVERSITY PRESS

LONDON : GEOFFREY CUMBERLEGE

AMEN HOUSE, E.C. 4

1947

FORESTRY

CONTENTS OF VOLUME XXI, NUMBER 1

British Forestry. By LORD ROBINSON 1

Co-operative Forestry in Britain. By BRUCE URQUHART 6

Forestry in the Netherlands and the State Forest Service. With Plates I, II. By J. A. VAN STEIJN 14

The Bowmont Norway Spruce Sample Plots (1930–45) (*Picea abies* Karst. syn. *P. excelsa* Link). With Plates III, IV. By F. C. HUMMEL . . 30

The Strength of Home-grown Timber Pit-props. With Plates V, VI. By F. H. ARMSTRONG 43

Utilization of Home-grown Larch in Great Britain (*Larix decidua* Mill. syn. *L. europaea* DC.). With Plate VII. By JOHN T. SMITH . . 77

The Fine Structure of the Fibres of Normal and Tension Wood in Beech (*Fagus sylvatica* L.) as revealed by X-rays. With Plate VIII. By R. D. PRESTON and V. RANGANATHAN 92

Bats. By J. M. D. MACKENZIE 98

Society's and Other News 108

REVIEWS

Longleaf Pine (W. G. WAHLENBERG). By W. M. MCNEILL 110

Forest Soils (H. J. LUTZ and R. F. CHANDLER). By H. M. STEVEN . . 111

Soil Fertility, Renewal and Preservation (E. PFEIFFER). By G. K. FRASER . 112

Forestry and Woodland Life (H. L. EDLIN). By M. L. ANDERSON . . 115

Our Forests (W. H. ROWE). By J. ALAN B. MACDONALD 117

Forestry and Forest Products: World Situation 1937–46 (Food and Agriculture Organization of the United Nations, dated 15th August, 1946). By THE EDITOR 119

NOTICES

Forestry. (Young Farmers' Club Booklet No. 20.) By H. L. EDLIN . . 124

Knot-free Red Pine by De-budding. By A. BICKERSTAFF 124

Fire Control Notes, Vol. 7, No. 3, Vol. 8, Nos. 2 and 3. (Forest Service, U.S. Dept. of Agriculture, Washington) 125

Extracts from *Science*, *Forestry Abstracts*, &c. 126

PRINTED IN GREAT BRITAIN

SOCIETY OF FORESTERS OF GREAT BRITAIN

THIS SOCIETY was formed in 1925 and adopted its first Constitution at Oxford in 1926. The object of the Society is to advance and spread in Great Britain the knowledge of technical forestry in all its aspects.

The Society consists of Professional and Ordinary Members. Professional membership is divided into two orders:

FELLOWS, being holders of a degree or diploma in forestry, and subjects of the British Crown, but not necessarily resident in Great Britain; and

ASSOCIATES, being subjects of the British Crown resident in Great Britain, whole-time foresters, and not eligible for Fellowship. They pay a less subscription than Fellows but have almost equal privileges.

Ordinary membership is open to persons not eligible for either of the above.

Office-bearers and Councillors are nominated by Professional Members, and in the event of competition for any office a postal ballot of the whole Professional membership is held. The following were elected to serve in 1947:

President:	W. H. GUILLEBAUD, B.A., Forestry Commission.
Vice-President:	OWEN J. SANGAR, M.C., Forestry Commission.
Editor of Journal:	C. W. SCOTT, O.B.E., D.F.C., B.SC., 'Downhill', Ellesborough Road, Wendover, Aylesbury, Bucks.
Business Editor:	J. ALAN B. MACDONALD, 35 Manor Place, Edinburgh, 3.
Secretary and Treasurer:	R. ANGUS GALLOWAY, M.C., B.SC., Solicitor, 8 Rutland Square, Edinburgh, 1. Tel. No., Edinburgh 23842.
Auditor:	D. L. FERGUSON, 25 Drumsheugh Gardens, Edinburgh, 3.
Councillors:	C. A. CONNELL, M.A. E. V. LAING, M.A., D.SC. C. H. THOMPSON, M.A., DIP. FOR. A. H. GOSLING, B.SC. RAY BOURNE, M.A. B. J. RENDLE, B.SC.

THE SOCIETY AND ITS JOURNAL

THE IMPORTANCE OF FORESTRY is being realized more and more in Great Britain. The number of foresters is increasing steadily, and a forestry profession is gradually being built up. It is intended that this Society should be representative of the profession. Those who are not engaged in the practice of forestry or the allied sciences are cordially invited to join the Society as Ordinary Members.

SUBSCRIPTIONS are:

Fellows and Ordinary Members: £1. 1*s*. 0*d*. annually or £10. 10*s*. 0*d*. for Life.
Associates: 10*s*. 6*d*. annually.

THE SOCIETY'S JOURNAL, called *Forestry*, is usually published twice a year, in June and December. It provides a means for the publication of the results of practice and research both in the growing of timber and in its utilization, including such basic sciences as forest physiology and ecology, forest soils, wood structure, and timber physics, and allied sciences such as forest entomology and forest mycology.

CONTRIBUTIONS may be accepted from members and others resident either in Great Britain or abroad. They should be sent to the editor, C. W. Scott, 'Downhill', Ellesborough Road, Wendover, Aylesbury, Bucks. No article should be submitted which is being offered to any other journal for prior or simultaneous publication. Articles should be typewritten, and must be in a final form suitable for publication. References to literature should be collected at the end of the paper, and arranged alphabetically according to author's name, and numbered. In the text each reference should be indicated by its number enclosed in brackets. Each article should conclude with a summary. It should give the methods, extent of material, observations, and results, but should be brief and not exceed 3 per cent. of the original. It is understood that the author waives any copyright or translation rights in such summaries and that their reproduction in other publications will be permitted, subject to the source being duly acknowledged. Twenty reprints of the article will be sent free to each contributor and a reasonable number may be purchased by the contributor if ordered when the proofs are returned. The Society as a body takes no responsibility for the views expressed by contributors.

Forestry is sent free to members of the Society; others may register as subscribers by application to the Secretary, R. Angus Galloway, 8 Rutland Square, Edinburgh, 1.

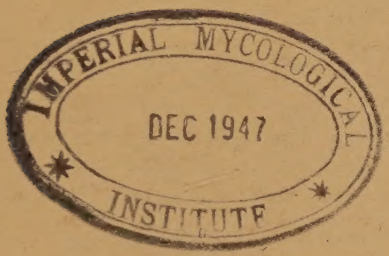
SOCIETY'S MEDAL. For the rules concerning the award of this Medal see vol. xx, pp. 80–1.

FORESTRY

THE JOURNAL OF THE SOCIETY OF FORESTERS OF GREAT BRITAIN

Edited by C. W. SCOTT

VOLUME XXI : NUMBER I



Price
Seven Shillings and Sixpence

Published by the
OXFORD UNIVERSITY PRESS
LONDON: GEOFFREY CUMBERLEGE
AMEN HOUSE, E.C. 4
1947

BRITISH FORESTRY

By LORD ROBINSON

(*An address delivered in London on 20th March 1947 to the Society of Foresters of Great Britain when the Society's medal for eminent services to British forestry was presented to the speaker.*)

I HAVE chosen as my title for to-night's address that which I employed exactly 20 years ago in writing the first article of the first number of *Forestry* (Volume I, Number 1, 1927).

Volume I was devoted largely to a review of British forestry, which I attempted in broad outline and others in more detail. I will not give the full list but note as examples Steven on 'The Silviculture of Conifers in Great Britain' and Guillebaud on 'Silviculture of Hardwoods in Great Britain'. There were also some articles on forestry in Norway, Denmark, and Finland.

I find my paper was divided into three parts, namely: Policy, including both current and future policy; Forestry Technique; and Utilization; with, by way of an introduction, a little homily of two paragraphs on the practising forester, the limitations under which he works, and the ideals to which he might aspire. I will omit the homily on this occasion, but retain the main heads.

FOREST POLICY.

In 1927 we had left the first world war some 9 years behind; we had been through the throes of the Geddes Committee; completed a census of woodlands, and could therefore make a reasonably intelligent appreciation of our forest resources and problems. We were speeding up the Commission's rate of planting and hoped to advance from 23,300 acres in 1927 to 30,000 acres in 1929. I added, however, by way of comment, that this was all too slow. Private planting was not doing more, if as much, than keep progress with current fellings. At the projected rate it would take 50 years to fulfil the Acland programme, or, if our energies were devoted wholly to replanting, some 16 years to replace the existing felled area. It seemed clear that 'if an adequate reserve of growing timber is to be maintained in this country, the State will have to come more and more into the business, and that the scale on which it should operate is likely to be influenced less by the rate of planting which is deemed desirable than by financial considerations'.

That final reservation proved to be only too true. The economic crisis, leading as it did to the Report of the May Committee (1931), had as its outcome the imposition of severe restrictions on the finance of the Commission for the succeeding 5 years.

By 1938 we were beginning to pick up again, but in 1939 came the war and the second great attack on our resources of standing timber. I do not propose to devote time to that business, which, for adequate treatment, would take more than the whole of the time which I have at my disposal.

To proceed with the general history of Forest Policy—in 1943 the Commission issued two White Papers dealing with forest policy in general and with private woodlands in particular. The forest policy there advocated, so far as the size of the industry is concerned, does not differ very materially from that put forward in 1919. The final objective in each case is, nearly enough, 5 million acres of well-managed forest. The main difference is in respect of private forestry. The Commissioners' experience since 1919 had led them to realize that unless continuity of management can be secured, the large area of forest under private management will never be brought into a really productive state. It was unthinkable, after what had happened, that the woodlands should not be rehabilitated, and the only way out seemed to be the Dedication Scheme, of which a great deal has been heard since the White Papers were issued.

To continue my narrative, a new Forestry Act was passed in 1945, placing the Commission under the Minister of Agriculture and the Secretary of State for Scotland jointly. A new Commission was appointed in July 1945. In November 1945 the Minister of Agriculture announced the Government's Forest Policy in the House of Commons and stated that the Chancellor of the Exchequer proposed to ask Parliament to replenish the Forestry Fund by £20 million during the 5 years 1946–50, which sum should provide for the afforestation and replanting of 365,000 acres (this being the first 5-year quota of the Commissioners' proposal to afforest 1,100,000 acres in the first decade), and for all ancillary expenditure such as education, research, and housing.

The latest development has been a road-making scheme in the Commission's forests associated with Polish and British unemployed labour. At the time of writing this scheme is in its initial stages and there is little progress to report.

Looking back over forest policy, it is interesting to notice how history tends to repeat itself. In 1927 I was saying that the forestry policy recommended by the Acland Committee was drawn up in 1916–17 when the full extent of the war fellings was not foreseen. I can say again to-day that the Commissioners' White Papers of 1943 were drawn up in 1942 when the full extent of the war and post-war fellings was not foreseen. The devastation on this second occasion has in fact proceeded farther than was anticipated and is not yet at an end.

Again, it is to be remarked that the Geddes Committee, sitting in 1921 barely three years after the end of the 1914–18 war, seriously questioned the necessity of growing timber in this country, and categorically stated that no timber should be grown farther than 6 miles from a railway. To-day, less than 3 years after VE day, and while we are still in the emergency, people write to the newspapers complaining of the activities of the Forestry Commission. Quite clearly we are not yet a forest-minded people.

FORESTRY TECHNIQUE.

In 1927 the Forestry Commission had been at work only for 7 years—a period not long enough to enable it to claim any great successes; nor, perhaps, long enough either for some failures to manifest themselves. Nevertheless, there were

already certain encouraging results to be observed. Under Forestry Technique I made the following statements:

'Probably the greatest advances which have been made in recent years are in connexion with poor sites, chiefly through ecological studies. Molinia peats can now be dealt with. The next but more difficult step is to learn how to treat the heather types of moorlands.'

And again:

'Briefly, the note which it is desired to sound in this brief sketch is that, while it is necessary to go ahead with large-scale operations, there is a great need for research work and forest investigations and for the application of experimental results to practice.'

I would put the turf-planting of spruces as the biggest technical advance made in the early years. The method was evolved only after a good deal of investigation, which was beginning to fructify rather more than 20 years ago. Turf-planting did not catch on quickly with the older foresters (indeed a certain amount of persuasion was needed), but by 1927 J. M. Murray in the Forest of Ae and Hopkinson in Smales (Kielder) had begun turf-planting on a large scale, and having seen the advantages of the method we have never looked back. I estimated at the time that turf-planting and the associated work would enable us to deal effectively and relatively cheaply with some hundreds of thousands of acres in the hill country, and especially on the Border, which we had hitherto considered of doubtful planting value.

Turf-planting, though specially effective in grassy areas, was not a universal panacea. We had large areas of spruce in check on heather ground, for example at Inchnacardoch and Allerston, and turfing, even with the use of basic slag, was rarely effective. A new method was required and in 1930 the first large-scale experiment was made at Allerston with caterpillar ploughing. We had been ploughing with horses and Fordson tractors since 1919, but it required the extra power and grip provided by the caterpillar to work the heavy ploughs which alone would go deep enough to break up iron pan and push aside boulders weighing 3 cwt. or more. Since 1930 there have been considerable developments in the design of ploughs, which were the initial weakness in the combination, and in the application of the method to soils of various types, including not only those which need aeration, but drainage as well.

It would be difficult to overrate the additional command which deep ploughing has given us over the afforestation of poor types of ground; but in my view it is not the complete solution. On some of the heather areas which had been well ploughed spruce still remained in check, but after being interplanted with Scots pine took a new lease of life and proceeded to grow vigorously. The solution on such sites, so far as we can see at present, is in mixed pine and spruce planting on deep ploughed ground. Steven forecast this in his article in the same number in 1927, and the experiments which were started about 1927 at Allerston, Teindland, and elaborated later at various places, have yielded valuable supporting data. I go a good deal farther, however, in advocating mixtures of which pine is a

constituent and would apply it also to reasonable heather-clad soils for Douglas, *Tsuga*, and, on bare chalk and limestone downs, for beech.[1]

If these improvements in methods are to be counted to our credit, we have unfortunately the failure of young larch plantations on quite an extensive scale to place on the debit side. This larch problem seems to recur at long intervals of time and nearly always catches the forester on the wrong foot. We have still a lot to learn about the silviculture of European larch.

As regards hardwoods, in 1927 we were in some doubt as to methods of making oak plantations. In course of time, however, and as the outcome of numerous experiments, it has become apparent that there is no inherent difficulty in raising pure oak plantations provided the soils are reasonably suitable and that weeding of the young plantations is effective. I think, however, that there is still a good deal to learn in the way of cheapening weeding costs, and planting costs, provided we do not strive after the impossible, that is to say after the perfect plantation. I am not at all satisfied that the great numbers of oak plants which we have hitherto put in to the acre are really necessary. Coniferous nurses complicate the whole business and in the majority of cases do far more harm than good.

As regards beech, I have already referred to the effectiveness of pine nurses, and I believe that, provided the land can be ploughed, birch nurses can be used to the same or even greater advantage.

Ash and sycamore are still difficult problems and we cannot pretend that we have yet discovered the best silvicultural methods of growing either. I am inclined to think that small groups interspersed with other species, for example pure beech, will be the solution, but that it will be found necessary nevertheless to resort to green pruning of selected stems.

Devastated woodlands. A problem of outstanding importance and difficulty is the regeneration of the great areas of devastated hardwoods. In many cases there is extensive coppice growth or seedling birch already on the ground and much of it so advanced in growth that clear felling and replanting is practically out of the question at present-day costs. This problem was foreseen some years before the war, and experiments based on group regeneration were initiated. By prompt action it should be possible to do a good deal in that way, but I think also that we shall have to accept and cultivate properly a good deal of birch regeneration. This will not necessarily be a hardship, because birch is an excellent timber and well worth more attention than it has received.

I have had to restrict my remarks on technique to what I consider the most outstanding points. I have, for example, said nothing about nursery technique. There are great possibilities of improvement and it is necessary to exploit them. I think that our next big advance lies in that direction.

UTILIZATION.

Under 'Utilization' I made the following remark in 1927:

'. . . in the course of the next fifteen to twenty years, the considerable areas of plantations

[1] 'Some Ecological Aspects of Afforestation and Forestry in Great Britain', in *Forestry*, vol. xvi, 1942.

now being formed will be yielding small thinnings. The utilization of this produce will be a considerable undertaking, but it is believed that there will be no difficulty in disposing of it to the mines and elsewhere.'

Whether that optimism would have been realized under normal conditions it is difficult to say, but it must be pointed out that during the first decade of the 20 years it would have been almost impossible to sell the bulk of first thinnings. From 1939 onwards the position was changed completely. There is no need to detail the experiences of the war. In the famine conditions which prevail to-day wood of any sort is saleable and in most cases saleable at high prices. I would judge that this state of things will go on for several years at least. It is fortunate, in so far as the thinning of our extensive young plantations is concerned, that such a ready market exists for first thinnings, and I am hopeful that by studying the question with care we shall be in a position, if and when things return to normal, to market in a systematic and economic fashion. It is important, for example, to develop enterprises such as the manufacture of wall-boards, which consume crooked and small coniferous timber.

I would like to add just a few miscellaneous notes. The first is the layout and provision of roads in the forest. We have learned by bitter experience how important it is to have good road systems and how inconvenient to have to construct them in time of emergency. We are at present making use of unemployed and Polish labour to construct roads which are badly needed for the extraction of thinnings. I think that it will be found that from time to time there will be a demand for the employment of people who are out of work, and that if schemes are prepared in advance forestry can provide much useful employment.

The pressure for land for forestry and agricultural purposes is such, I think, that we should be well advised to start reclaiming difficult forest sites as such opportunities offer. Sir John Stirling Maxwell's experiments at Corrour, and our own with ploughing, show that soil cultivation is often at the root of the problem.

CONCLUSION.

I am going to end on an optimistic note. I am convinced that forestry will slowly win full recognition and that the 5 million acres of well-managed forests which I have always had in mind will ultimately be secured. I will not venture even a guess as to how long it will take to get there, but it may not be as long as many suspect. I can see a very great difference in public opinion as compared with the time when I began nearly 40 years ago. We now have flourishing plantations—goods to display in our shop windows—and people are beginning to take notice.

Again I am confident from the success which we have had in the past that a number of the problems which worry us to-day can be overcome by research and persistent endeavour.

CO-OPERATIVE FORESTRY IN BRITAIN

By BRUCE URQUHART

IT is now generally recognized that the whole basis of our national economy has changed. We can no longer afford to import the cream of the world's timber and let our own resources turn sour. No longer can we look complacently upon our continental neighbours, disparaging their somewhat crooked telegraph poles, their frugal use of every twig, and their elaborate systems of management. The time has come to adapt ourselves rapidly to the new conditions and avoid the mistakes of the past. For example, after World War I not more than a quarter of our felled areas were restocked and the national forest policy concentrated upon afforestation of grass and moorland. Now the new Forestry Act provides for the reconstitution of the larger felled areas by the scheme of dedication, and the Government appears sincere in its intentions to attack all forestry problems with vigour. It is, however, essential to recognize that the majority of productive forest land is in private ownership and that the units of ownership are often small and scattered. Their value is not diminished by this feature, in fact they may be as important as any concentrated national forests because they supply local domestic needs and are less liable to damage by fire and epidemic disease. In this category should be included not only the units of 100 to 300 acres but small woods of 5 and 10 acres, shelterbelts, and even hedgerows. In the census of 1924 6·9 per cent. of the nation's total woodland consisted of 'amenity woods and shelterbelts', and it is estimated that the aggregate of small woods under 300 acres must approximate a million acres.

PRIVATELY OWNED WOODLAND.

State ownership may not be the panacea for problems of forest management. In Norway and Denmark, as in Britain, 75 per cent. of the forests are privately owned, and over 60 per cent. in Italy, France, and Czechoslovakia (8). Exclusive of forests owned by townships, State forests seldom occupy more than 25 per cent. of any western nation's woodland.

Relatively small areas have usually proved difficult to bring under the influence of applied forestry, as indicated by yields. For example, the German farm forests produced per hectare half that of the State forests (3), though in Denmark (4) the yields of each are almost similar. In the United States (9) over 138 million acres are owned in woodlots averaging 50 acres, and the majority are said (4) to be understocked and indifferently managed.

Few nations have attempted direct control of small areas and the most successful measures of improvement seem to have depended upon arousing the enthusiasm of the landholders. For example, in Italy the co-operative methods applied to the control of erosion and floods by the Bonifaca proved that in local agrarian populations considerable latent powers of organization could be

developed. Professor Pavari of Florence (5) has emphasized the need for local leadership in launching any forestry projects, since they inevitably affect the surrounding population. Once the interest of the local inhabitants had been aroused and local leaders appointed, planting for soil conservation became popular and the Government's responsibility declined to giving technical and financial help.

A similar background would appear necessary in developing such projects as shelterbelts in Scotland.

In Denmark, where 36 per cent. of the forest land is owned in lots of less than 50 hectares, remarkable progress has been achieved by co-operative methods, following upon agricultural co-operative systems and the enthusiasm aroused by the Danish folk schools of the nineteenth century.

Without the same background on which to found co-operation it has been necessary in many other countries to initiate it by education. For example, in the United States, under the Tennessee Valley Authority, demonstrations of management for sustained yield (7) have led to increased co-operation among owners and operators. Work of this kind, already advanced in agriculture, is undoubtedly effective among the owners of small properties, especially where costs and returns of each operation are given.

A remarkably successful series of thinnings was recently demonstrated by a branch of the Royal Scottish Forestry Society in north-east Scotland, where details of the costs and returns gave growers an accurate picture of each operation. The educational activities of both the Royal Scottish and the Royal English Forestry Societies are well known and widespread in Britain.

Technical service must follow education, but neither appeal to the private grower unless based on sound commercial practice. It is also this close relationship to the economics of commerce which makes private forestry an important corollary to State forestry.

TECHNICAL ADVICE.

The Forestry Commission have stated in para. 168 of their Report on Post-war Forestry (1) that relatively small woods should supply the demands of local markets, and in para. 170 they mention the possibility of 'forest regions' comprising State and private woods in economic groups. Thus, since felling licences are to continue, it is probable that the Forestry Commission will balance yields regionally. That is, each district will be regarded as an entity, and possibly many units of ownership will be grouped to form a series of age classes. Restrictive cutting alone will not suffice to build up stocks of timber and cannot be rigorously applied while domestic needs are so intense. But the woodland owner can improve his stands by selective felling, since inferior qualities of produce are more saleable now than for at least 30 years. Since it is often the smaller areas which have escaped acquisition during the war, it is suggested that considerable stocks of scarce age-classes will be lost by unskilled exploitation. Thus it is advice specialized on thinning and utilization which is as urgently required as any on afforestation; and in other countries it is this type of work which seems to have benefited woodland owners more than any other (4).

The Forestry Commission offers advice to private owners, but it is questionable how far this service can be extended. Not only its own programme of afforestation but the launching of the scheme of dedication will absorb its limited staff for many years. In parts of Europe and in the United States university-trained foresters are employed by estates owning forests of more than two or three thousand acres; and where co-operative systems have developed, consultants manage groups of smaller areas. Similarly in Britain a few consultants have established practices, either managing woodlands or providing intermittent advice. Some have in addition supplied materials and acted as contractors. Despite the demand caused by an awakened interest in forestry, the factor limiting the extension of such enterprises is usually the excessive amount of travelling involved. Examples are known of consultants travelling over 20,000 miles a year, which of course means an unnecessary waste of time and expense to all concerned. In the U.S.A., Reynolds (6) writes that the American Society of Foresters complain of excessive travelling and duplication of work by forest consultants in New England.

Therefore there appears to be a demand for forestry advisers experienced in the intricacies of managing scattered private woodlands, but efficiency must depend to some extent upon the concentration of effort they can give to a particular region.

That a woodland owner is prepared to pay for such service has been proved by the gradual increase of consultants, and Reynolds (6) states that the owner of small units of woodland in the U.S.A. has obtained about 50 per cent. more for his products by employing consultants, and at the same time improved his growing stock. He suggests that for this reason alone growers are willing to pay for such service.

CO-OPERATIVE FORESTRY.

Objectively, therefore, British woodlands in private ownership, especially the smaller units, require some co-ordinating plan which will make them more productive without destroying their identity. In Denmark, where distribution of woodland and population closely approximate those in Britain, co-operative forest societies appear to have succeeded (4). As an indication of their popularity among woodland owners, membership steadily increased up to 1,800 by 1939, and the Danish Government has recognized their importance by contributing since 1919 to the salaries of the consultants employed by each society. What opportunities are there, therefore, in Britain for a parallel development? Kissen (4) has described the three co-operative movements in British forestry up to the year 1939. Since then one, the South Devon Woodland Owners, in existence since 1935, has been discontinued, leaving the Northern Forest Products in north-east England and the Landowners' Co-operative Forestry Society in Scotland. The latter society was founded in 1910, only 6 years after the first Danish society, and by 1939 included 339 members owning a total of 172,000 acres of woodland, representing about a third of the privately owned woodland of Scotland (1924 census).

Since April 1946 the writer has been engaged by the Landowners' Co-operative Forestry Society as its forest officer, and therefore the following remarks are largely based on experience in Scotland during the last year.

All three societies have derived revenue mainly from commissions on sales of timber, and since the war such sales have declined. In fact the Landowners' Co-operative Forestry Society showed a loss in 1945 for the first time for over 20 years. The other main source of revenue has been from the subscriptions of members. The question therefore arises whether membership can be increased to balance the losses from commissions on sales. It was decided by the managing committee of the Landowners' Co-operative Forestry Society that however desirable increased membership, adequate services must be offered to justify such expansion. The advantages of wholesale purchase through a co-operative society are obvious but, as suggested by Kissen (4), may not be fully utilized by its members. Agricultural co-operatives have well-developed trading organizations which include advertising and sales staff. The aspects of salesmanship cannot be ignored, and the forestry societies do not appear to have attempted any serious campaign to supply the full range of materials required in forestry. An efficient society should not only be able to obtain any of its members requirements at reduced prices, but also ensure correct designs of machinery and tools, qualities of plants and strains of seed.

From a member's viewpoint it may be necessary to sacrifice the pleasures of personal transactions with local firms, but the same business methods must be applied to forestry as to any other enterprise. It should be realized that the manufacturer and the nurseryman also benefit from orders in bulk. As more working plans are adopted, future requirements of stock will be known, and a co-operative society is the ideal organization to co-ordinate and distribute orders to the trade, which in turn can reduce costs of production. Unfortunately the scarcity of all materials does not encourage rapid development of trading activities at the moment, but a society should possess the bargaining power to obtain some priority of supply.

With the advent of the dedication scheme the demand for technical advice has increased and expanding membership places a further strain on a society's staff. Since the area covered by the Landowners' Co-operative Forestry Society extends from the Hebrides to the Border, one forest officer could not satisfy all its members; and yet its financial position does not allow the employment of additional staff. It was therefore decided to constitute a panel of consultants. As a result of several meetings sufficient experienced men have been found to undertake advisory work in all the main areas of Scotland. This panel includes three university-trained foresters, and agreement has been reached as regards fees and standards of conduct. Only full-time consultants have been selected, and it is hoped that as the Society expands, a service will develop which will concentrate the work of each consultant within defined areas. Perhaps as important as advisory work is the demand for mobile labour. It has not been considered practical for the Landowners' Co-operative Forestry Society to organize its own mobile gangs. Therefore a list of contractors prepared to undertake any forestry

work has been compiled. These include timber merchants as well as smaller local enterprises. It is intended that the Co-operative Society should act as the intermediary between woodland owner and contractor, and the Society's consultants should function as forest architects. Thus correct specifications and costs can be standardized, and both grower and contractor can be assured of reasonable treatment. This procedure opens up many possibilities, including the extension of piece rates to almost any forest operation. Already certain small units of ownership, under 300 acres, retain no residential forest staff, and the sporadic work required in their woods is undertaken by contractors under the supervision of a consultant. Such methods should prove the most economical for small estates, especially where the owner and agent cannot give the time necessary to supervise full-time labour. The additional cost of contract work is off-set by eliminating wasted effort due to lack of supervision.

CO-OPERATIVE GROUPS.

With the necessary framework for extension, membership of the Landowners' Co-operative Forestry Society has been increasing, and 1946 has seen the largest increase since its foundation.

To avoid over-centralization it was considered essential to form regional associations or groups of estates upon which to devolve detailed executive work. Three pilot groups are being formed, one in the north-east, one in central, and one in west Scotland.

The personal element in any such organizations, which are entirely voluntary, means that progress is slow and only on the firm basis of demand can they succeed. Thus a few groups built up on patient experience will show whether there is indeed a field for that degree of co-operation practised in Denmark, or whether British conditions are not yet propitious.

In broad outline the following objects may be defined:

1. To form a group of all woodland owners in a region. The size of the area will vary but should not exceed 40 square miles (cf. Danish Co-operative Societies (4)). Included in the group may be timber merchants and contractors and any such body as will further the interests of the group.
2. All members to belong to the parent Society, but the group to employ its own local manager who may be one of the Society's consultants or a local member experienced in forestry.
3. To promote co-ordinated supplies of materials and labour, and to direct their use by a management committee composed of members of the group.
4. All marketing of produce to be through the group.

A short discussion of the progress made so far will show where the problems lie. First, it seems essential that at least two woodland owners within a region support the plan enthusiastically. The owner of large woodlands should not stand without the scheme, though at first it may not seem to his advantage to be included. Not only can he contribute to launching it, owing to the possession of facilities such as nurseries, skilled staff, and machinery; but he will benefit from co-ordinated control of vermin, attraction of new markets, contractors, and

exchange of seeds and plants. It is, however, only fair that such an owner should not be expected to contribute more than his share in order to benefit the less progressive estates. The aim should be to raise the whole level of management and not drag it down to an average standard. In north-east Scotland it has been the owners of the largest areas who have initiated the movement, and as a result one has agreed to provide a central nursery for the raising of certain species of seedlings. Already a waste-land nursery has been established and steps taken to select strains of seed. Secondly, a firm of timber merchants already working in the region has agreed to undertake thinning, brashing, and planting on contract, and has already started the mechanical grading of roads.

Similarly in central Scotland the largest woodlands will form the basis of a group.

The Society's forest officer has started to prepare the working plans for those woodlands in certain groups where dedication has been decided upon. In north-east Scotland approximately 8,000 acres will be included in one group.

It is possible that the maintenance grant, offered by the Forestry Commission, of 3*s*. 4*d*. an acre for all stocked woods might be paid into a pool to finance the payment of a forest manager and the overhead expenses. This grant, subject to income tax, is negligible to an individual estate but should be sufficient to launch a group, but further experience is required before the financial system can be discussed in detail.

In some instances it appears advisable to avoid burdening a group with too great financial commitments at first. It is also important not to add unnecessary accounting or paper work to its other functions, since even dedication implies not inconsiderable form-filling. For these reasons certain groups may develop, and there is a tendency for this to happen already, in the form of loose associations, using the services of one consultant in a region while each member belongs to the parent Society. Such formations should evolve into more defined groups if the demand increases, but that will largely depend on the consultant's efforts to co-ordinate the work in his area. Just as in agriculture, a considerable degree of co-operation can take place without formal recognition. For example, farmers often share equipment such as chemical sprayers or lend each other implements without working through a defined organization. However, it is usually the consultant or forest manager who is in the best position to know the requirements of a number of scattered woodland owners and arrange for such exchanges.

In general the Co-operative Society aims to encourage individual enterprise and use existing facilities rather than set up rival organizations. Thus the machinery or transport, &c., of one owner may be more fully and economically employed by several members. To avoid complicated accounting, individual purchase and hiring is considered better than communal purchase.

It is surprising how much expensive machinery is owned by scattered estates and is not in full use. Also the developing techniques of mechanized forestry will demand increasingly expensive tools. These should either be owned by a contractor, probably the most likely to use them efficiently, or by a proprietor who is

assured that the depreciation on capital outlay will be covered by constant use. Forestry has an advantage over agriculture in that its machinery can be used over longer periods and is not all required at once within a short season.

From what has been described it will be appreciated that successful co-operation will depend greatly on tact and enthusiasm and on a determination to overcome the many difficulties which will arise. Each specialist in the industry of forestry has a part to play, whether it is timber merchant, nurseryman, grower, or forester, and their efficiency can only be increased by frank discussion of their problems. This discussion should be localized within a region. There is quite enough centralized exchange of opinion on higher levels, and a tendency sometimes for such exchange to evaporate in a fog of generalization.

FINANCE.

Experience in other countries indicates that co-operative societies require some financial assistance to survive. In Denmark the Government pays half the forest manager's salary and expenses when a society includes more than 2,000 acres and 25 members. Grant (2) has suggested Government assistance in the form of profit sharing.

If the Landowners' Co-operative Forestry Society, for example, is to develop along the lines suggested, some revenue other than fees, commissions, and subscriptions is necessary, at least for the next decade.

A society's forest officer cannot devote sufficient time to founding regional groups, attending meetings, and keeping abreast of research if his salary depends mainly on revenue from fees earned by direct advisory work.

It is suggested that much of the advisory work promised by the Forestry Commission, especially to small units of woodland, can be undertaken by a co-operative society. Not only existing small units of woodland could then contribute more fully to the nation's supply of timber but new areas on farms and small properties could be afforested. It is noteworthy that four county councils are now members of the Landowners' Co-operative Forestry Society, and there is scope for developing municipal forests similar to those in France and Switzerland.

It is true that any Government grant to a society will entail Government supervision, but since the Forestry Commission with its increasing areas of forest will usually be closely associated in any regional group, a co-operative society would benefit by having a representative of the Commission on its board. Audited accounts, essential in any event, would be available to the Government, and the advantages of financial help at a critical stage would outweigh possible State interference.

Finally the fact that growers would be contributing largely towards the cost of the help they received would mean that the advisory service promised by the Government would be implemented at a much lower cost to the taxpayer.

No Government department is willing to spend public funds on a project unless it is reasonably assured of its success. It is suggested there is sufficient evidence of eventual success, but the rate of progress, without financial stimulus, will be slow at a time when it should be most rapid.

The pioneers of co-operative forestry in Britain deserve the recognition which has been given to similar organizations in other countries.

SUMMARY.

Small scattered units of woodland, a feature of British forests, are considered of great potential value. The problem of improving the standard of management to raise their yield is discussed, and systems developed in other countries are compared. Co-operative societies appear to be the solution, since they imply that enthusiasm of the participants so essential to the success of any plan of reconstruction. After describing the co-operative forestry societies existing in Britain, lines of development are discussed, with special reference to the Landowners' Co-operative Forestry Society. Recent progress indicates that as a co-operative society develops it must devolve part of its work upon regional groups, and their organization is considered.

If their progress is to be rapid and assured, some financial aid by the Government is required, similar to that granted by the Danish Government, where part of a society's forest officer's salary and expenses are paid by the State. Such recognition would implement the Forestry Commission's promise to assist owners of woodlands with material advice and would provide a more elastic and workable service than any attempt to administer small scattered areas by Government officials. The cost of subsidizing co-operative societies would be less than the cost of a direct service by the State.

LITERATURE REFERENCES.

(1) Forestry Commission (Great Britain): *Post War Forest Policy.* H.M. Stationery Office, 1943.
(2) Grant, J. R.: 'Problem of Small Woods'. *Quart. J. For.* 1946, xl (2).
(3) Heske, F.: *German Forestry.* Yale Univ. Press, 1938.
(4) Kissen: *Co-operation in Forestry.* Tech. Comm. No. 2. Imperial Forestry Bureau, Oxford, 1944.
(5) Pavari, Professor of Forestry at Florence (unpublished work).
(6) Reynolds, H. A.: 'Small Holdings'. *Am. J. For.* xliii (10), 1945.
(7) Seigworth, K. J.: 'Forest Management of Private Lands in T.V.A.'. *Am. J. For.* xliii (10), 1945.
(8) Troup, R. S.: *Forestry and State Control.* Clarendon Press, 1938.
(9) U.S.A., Dept. Agric. *Forest Service Report, 1939.*

FORESTRY IN THE NETHERLANDS AND THE STATE FOREST SERVICE

By J. A. VAN STEIJN

(*Director of the State Forest Service in the Netherlands.*)

THE FOREST-AREA OF THE NETHERLANDS.

IN 1941 there were 249,900 hectares of forest in the Netherlands, consisting of—

Coniferous forest	173,400 ha.
Broad-leaved high forest	28,400 ha.
Coppice	39,600 ha.
Osier-beds	8,400 ha.

(1 ha. = 2½ acres = 12,100 square yards)

In that year the waste land covered an area of 298,000 ha., namely—

Heath and other waste ground	126,900 ha.
Dunes and sand-drifts	39,800 ha.
Moors and swamps	59,600 ha.
Lakes, pools, and fens	37,400 ha.
Pasture land formed by tidal silt	34,500 ha.

(Figures rounded to the nearest 100 hectares.)

Thus 7·6 per cent. of the total surface of the Netherlands are under forest and about 9 per cent. occupied by waste land.

The best wooded provinces are Gelderland and Utrecht, where 15·7 and 12·3 per cent. respectively are under forest, whereas the province of Groningen has the lowest percentage, only 0·3.

Though not belonging to the forests proper, the plantations along the roads and dikes in the Netherlands are important for wood-production. Placed in one single row these plantings would be almost 48,000 km. in total length.

From the above-mentioned figures it is apparent that the Netherlands is a sparsely wooded country, not only in comparison with other parts of the world, but also by European standards. For example, the percentage of forest in various countries is:

Sweden	56·6 per cent.
Germany	27·5 ,,
Norway	24·7 ,,
France	19·2 ,,
Belgium	17·8 ,,
Denmark	8·1 ,,
England	5·4 ,,
U.S.A. (commercial forest area)	26·0 ,,
Canada (accessible and productive)	22·2 ,,

Coming between Denmark and England the Netherlands is one of the most sparsely wooded countries of Europe.

The forest area, however, has been much smaller than it is to-day. According

to the returns the forest area in the Netherlands in 1833 amounted to only 169,000 ha., of which 32,000 ha. were coniferous and 137,000 ha. broad-leaved (high forest, coppice, and osier-beds), whilst the waste land occupied 889,000 ha. at that time.

In the course of a century an area of waste land of 591,000 ha. has been reclaimed, and the forest area has increased by almost 81,000 ha., or 48 per cent. The greater part of this increase is due to coniferous forest, which rose from 32,000 ha. to 173,400 ha., whereas the broad-leaved forest decreased from 137,000 ha. to 76,500 ha. The coniferous woods consist of Scots pine, for the greater part.

In the course of the years there has been a shift of the forest area from the better to the poorer soils, because many forests disappeared from fertile soil to make room for arable land and pastures, whereas the forests increased on the poorer soils unsuitable for agriculture.

As to ownership of the forest property there is also a change to be noted, parallel with the development of the State Forest Service and the afforestation of waste land with State subvention. Whereas some decades ago the private forests covered 81 per cent. of the total area, and the forests of the State and municipalities only 8 per cent. each, the division now is as follows:

State	15 per cent.
Municipalities, provinces and the like	15 „
Institutions and associations	5 „
Private persons	65 „

THE TIMBER POSITION OF THE NETHERLANDS.

The small quantity of forest makes it obvious that the Netherlands is not able to supply its own requirements of timber. Though the timber yield which every year can be cut from the Dutch forests and from the road-side plantations, without breaking into the stock, amounts to three-quarters of a million cu.m., and the importation amounts to 5,000,000 cu.m. on an average in normal times, the home-grown production is of special value. This is particularly so when import is entirely or for the greater part at a standstill, as the war of 1914–18 and that of 1940–45 have proved. Further there are a number of kinds of forest produce of low value, which are used near where they are grown, and, therefore, can be produced more efficiently at home than in other lands involving heavy transportation costs. For other uses the home product has to compete with the imported one, and a prejudice against the use of home-grown timber must be overcome.

In many cases the value of home-grown timber is still underestimated; it can often be used as well as the imported timber. Before the war a committee instituted for that purpose carried on propaganda for the use of home-grown timber. During the stagnation of imports there was an increase, if not in appreciation of home-grown timber then in the demand for it. Before the last war almost all the imported timber came from Finland, Poland, Sweden, Russia, and Lithuania.

The principal product of Dutch forestry is Scots pine; a great portion of it—in normal times nearly 125,000 cu.m.—is used as pit-props in the collieries of

South Limburg. This forms about one-third of the total use of pit-props which may be placed at approximately 350,000 cu.m. per year. Besides that, pine, especially the lighter sorts, supplies timber for farming and market-gardening (posts for fencing, drying-frames, bean-sticks, and the like). Further, the many waterworks in the Netherlands require a good deal of light posts to protect the banks of rivers and canals.

Oak and beech are used in the main as piles, as sawn timber for buildings, and in the wood-using industries. Elm is especially in demand by cartwrights and coachbuilders. Poplar occupies a special place. About 100,000 cu.m. come on the market in normal times, of which a considerable part is made into wooden shoes, whereas the smaller trees are used for the manufacture of matches. The beautiful heavy boles find a ready market in the plywood industry. In time of war this kind of tree has proved its many uses, and, therefore, increased poplar-culture is proposed.

THE CLIMATE AND THE SOIL OF THE NETHERLANDS.

Climate.

The Netherlands has a fairly mild sea-climate, with mild winters and cool summers. The humidity of the air is constantly high, and the cloudiness well marked in general (0·6–0·7), which also appears in the low percentage of sunny days (31 per cent.).

The wind is strong, 3 degrees Beaufort on an average (about 5 m. per second), and especially in winter the wind repeatedly passes into a gale. The prevailing wind comes from the south-west.

The average temperature of the year is 10° C., with a maximum of 19° C. in July and a minimum of 2° C. in January. The average rainfall amounts to about 700 mm. per year (644–728), and on about 210 days of the year it rains. The driest month is February, with 40 mm., while August is the rainiest month, with 80 mm. As a rule the spring is dry and the summer wet. Thunderstorms without rain rarely occur, so that forest-fires are seldom caused by lightning.

Evaporation is surpassed by precipitation by a wide margin.

Soil.

The Netherlands consists of a high section, which is hilly in many places, and a low, flat section. The former is to be found in the east, the centre, and the south of the country; it consists of diluvial sand, usually mixed with gravel. The lower western and northern part of the Netherlands, along the North Sea and the Zuyder Zee, is composed of alluvium, viz. sea-clay, river-clay, and bog-land. A great part of this region is below sea-level. Along the coast of the North Sea a dune region of varying breadth is found; the greatest breadth is about 4½ km. The sandy region can be divided into preglacial and glacial diluvium. The preglacial diluvium has been deposited by the rivers Rhine and Meuse; the glacial one by glaciers which in the Ice Age extended from Scandinavia to the centre of the Netherlands. For this reason the landscape locally has the features of an end moraine.

The soil of the higher heaths often belongs to the podsol type, i.e., a layer of bleached sand on moorland pan. Coatings of loam and layers of gravel are also found in the sandy soils.

In various places shifting sands are found, of which the largest, and the most extensive of western Europe, was on the Veluwe in the neighbourhood of Kootwijk (province of Gelderland), but now it has been largely afforested by the State Forest Service.

Silviculture is occupied almost entirely with the poor sandy soils. The fertile soils are devoted entirely to agriculture and horticulture. Even the sandy soils, once believed suitable for silviculture only, are being used for agriculture by modern techniques. This leaves only the lowest grades of sand for timber crops.

HISTORICAL SURVEY.

At the beginning of the nineteenth century the condition of the Dutch forests was far from favourable. The existing forests had been neglected for ages and suffered severely from constant mismanagement. Although fellings were rather heavy, seldom were measures taken to keep up the forests through regeneration. Further, through reclaiming for agricultural uses many forests were depleted, and removal of litter and cattle grazing took place on an extensive scale.

For a long time this untenable state of affairs existed, but through want of expert enlightenment and surveillance from the Government, radical improvements failed to appear. Also the measures taken during the French period (1804–13) were of small avail.

After the foundation of the kingdom of the Netherlands in 1813, the situation did not become better. Just as in the surrounding countries, so in the Netherlands, the opinion prevailed that forestry was not a matter for the State, and private persons were given a free hand. Even to an extensive scale parts of the existing Crown demesnes were sold to improve the bad pecuniary position of the Exchequer. There was no change in the position till 1850, when the demand for pit-props rose greatly in the surrounding foreign countries, and timber prices went up. The division of the common grounds, which about 1860 was made obligatory, freed vast areas of waste land for reclaiming. Many private landed proprietors were attracted by the favourable possibilities of the future, and the Dutch forest area increased considerably in this period. This was accentuated when the agricultural depression of 1870–80 made agriculture impossible on a great part of the sandy soils, so that much former arable land was transformed into forest. Almost all these afforestations consisted of Scots pine. This species of timber was much in demand, raising a crop was comparatively simple and cheap, and it exacted little nourishment from the soil.

Later on the growing use of artificial manure reversed the picture, so that more and more ground which had been exclusively suitable for forest could be taken under cultivation for agriculture. In consequence afforestation by private persons decreased more and more at the end of the nineteenth century. Moreover, private ownership did not lead to the creation of a permanent forest, because the pine woods were felled young and the timber was exported as mining timber, after

which reafforestation often failed to appear. The export reached such a volume about 1880–90 that it seemed as if the greater part of the forests would vanish.

This danger has led both the people and the Government to the idea that permanent forests are in the public interest. By degrees this has brought about a total change of forest policy. The sale of Crown demesnes had already decreased after 1850 and ceased entirely after 1897. In 1888 private persons followed the example of Denmark and established the Dutch Heath Exploitation Company. This institution has done many things to promote the reclaiming of arable land and pasture and to advance forestry. Quite a number of private landed proprietors engaged this company to cultivate their waste ground and improve pastures, arable land, and woods. In the beginning also the State charged the Dutch Heath Exploitation Company with the afforestation of some dune regions. In 1897 the Government broke finally with the system of estrangement of Crown demesnes which had prevailed during most of the nineteenth century. At the suggestion of the Government a bill had been passed for the purchase of about 2,000 ha. of shifting sand and 600 ha. of heathland for afforestation in the neighbourhood of Kootwijk (province of Gelderland). Here, too, the Dutch Heath Exploitation Company was charged with the afforestation, as a temporary measure. In other regions of the country also the authorities showed a greater interest in forestry, and measures were taken to advance the laying out and the expert tending of woods. Through this growing Government care the need arose for a special organization, and in 1899 it was decided to establish a State Forest Service.

THE TIMBER SPECIES OF THE DUTCH FORESTS.

Dutch trees can be divided into two groups, viz. natives and exotics, the latter imported from foreign countries. The number of indigenous species is comparatively small, considerably smaller than in corresponding regions of North America and Asia. The reason for this is probably that in Europe during the Ice Age many species disappeared, because their habitat between the ice-masses which came down from the north and the glaciers from the mountains stretching east and west became too limited, whereas in North America the mountains extending from the north to the south allowed a shifting of the growing region to the south. Later on, however, people imported again numerous species from elsewhere, and some of them have turned out to be a valuable gain for the Dutch forests.

Indigenous species are almost exclusively broad-leaved trees, such as oak, beech, hazel, birch, alder, and aspen. The great demand for coniferous woods, their faster growth, straighter boles, and the smaller claims (especially true of Scots pine) they make on the soil, resulted in coniferous forests replacing many broad-leaved ones, so that conifers predominate now.

Conifers.

The most important tree of the Dutch forests is the Scots pine (*Pinus sylvestris* L.) which occupies about 65 per cent. of the total forest area and upwards of 90 per cent. of the coniferous woods.

Though various other species have taken on very well in recent years, the Scots pine is still the most used timber tree, because of its cheap and simple culture and its small demands on the soil. The wood is at the age of 50 years already suitable for pit-props, whereas the heavier sizes are used as posts for buildings. It is not certain that the Scots pine can be called a native of Holland, though it was found here in large numbers in prehistoric times. Its numbers decreased very much, later on, until in the sixteenth century, with seed imported from Germany, pine woods were laid out again artificially.

The wide range of Scots pine (the whole of northern Europe and Siberia) resulted in numberless local and climatological races coming into existence. As these are by no means all suitable for Dutch silviculture, measures have been taken, as in many other countries of Europe, to ensure the proper origin of Scots pine seed. For that purpose a guarantee association was established in 1926. Its members have committed themselves to deal in and to grow exclusively seeds and young plants of Scots pine from Dutch forests, and have placed themselves voluntarily under the supervision of the State Forest Service in the matter of the collection of seed and the culture of pine plants.

On the worst sandy soils, especially the dune afforestations, there have been 60 years of success with Austrian pine (*Pinus nigra* var. *austriaca* Aschers et Graebn.) imported from the south-east of Europe and with Corsican pine (*Pinus nigra* Arn. var. *corsicana* Loud.).

Maritime pine (*Pinus pinaster* Ait.) from the south of France has been tried often, but it suffers much from late frost. Jack pine (*Pinus banksiana* Lamb.) imported from Canada and *Pinus rigida* Mill. did not come up to the high expectations which were entertained of them in the beginning.

White pine (*Pinus strobus* L.) on the contrary grows very well in the Netherlands, but the culture is all but impossible owing to the white pine blister rust (*Cronartium ribicola*).

Norway spruce (*Picea abies* Karst.), so important in adjacent foreign countries, is but locally of some significance in the Netherlands. These last years have seen success with Sitka spruce (*Picea sitchensis* Carr.). Trees from British Columbian seed give most satisfaction. Large areas, especially in the State forests in the province of Drenthe, are afforested with Japanese larch (*Larix leptolepis* Gord.) which grows considerably better than European larch (*Larix decidua* Mill.), the latter being subject to canker. The European larch has got a new chance, however, since the discovery of the Sudeten variety, which is but little sensitive to canker.

Recently Douglas fir (*Pseudotsuga taxifolia* Brit.), which shows very fast and straight growth in suitable soil, has been used on a large scale. The best strains come from the west coast of Oregon and Washington.

Species of *Abies* are found sparsely in the Netherlands. Perhaps the American white fir (*Abies grandis* Lindl.) offers good possibilities.

Broad-leaved Trees.

Oak holds the most important place among the broad-leaved trees. Two species are found in the Netherlands, viz. the pedunculate oak (*Quercus robur* L.) and the

sessile oak (*Quercus petraea* Liebl.). They are exploited both as high forest and as coppice. The latter was formerly of great importance for bark supplies, from which tannin was prepared. The import of foreign tanning materials, however, has made this silvicultural system superfluous, so that much oak coppice has been or is being transformed into high forest or arable land. The State Forest Service possesses one of the most beautiful oak forests of the Netherlands, the 'Liesbosch', near Breda.

Red oak of American origin (*Quercus borealis* Michx. f., &c.) is often used in the laying out of mixed forest.

Beech (*Fagus sylvatica* L.) is a species for the better soils. The best standing crops are found in the environs of Arnhem.

Of very great importance for the Dutch wood supply are the poplars, whose timber is much used for matches and wooden shoes. Of the numerous species and crosses, especially the American poplar (*Populus deltoides* var. *monilifera* Henry) and the Canada poplars (a group consisting of hybrids of a European and an American species) exist in great quantities. Though forest stands of poplars occur, in the main this tree is found along roads, dikes, and ditches between the arable lands and pastures. Especially in the eastern part of the province of North Brabant, in Limburg, and in Zealands Flanders the poplar is of great importance.

The high claims which the common ash (*Fraxinus excelsior* L.) makes on the soil explain why it is seldom seen in the forest. The timber, however, is of very good quality and suitable for various purposes.

The many other broad-leaved trees which occur in the Netherlands are seldom found as high forest. Among them the elm (*Ulmus* spp.) occupies an important place. This beautiful tree, which plays such an important part in the road-side plantings of the western and northern Netherlands, has suffered much in the last score of years from elm disease, caused by the fungus *Ceratostomella* (*Ophiostoma*, *Graphium*) *ulmi*. Up to now no effective remedy has been found, and numerous trees fall victim yearly, so that gradually the elm is disappearing from the scenery. Of importance for road plantations or as a mixture in coniferous afforestations are birch (*Betula pendula* Roth. and *B. pubescens* Ehrh.), lime (*Tilia vulgaris* Hayne), sycamore (*Acer pseudoplatanus* L.), and horse-chestnut (*Aesculus hippocastanum* L.).

THE STATE FOREST SERVICE.

Task.

In the beginning the task of the State Forest Service was exclusively the maintenance of the few existing State forests and the afforestation of waste land. In 1907 this task was enlarged through an arrangement to afforest waste land belonging to municipalities, with the help of State subvention. (See page 22.)

During the First World War the high price of timber made many private forest owners cut down and sell their standing crop. The reafforestation of the clear-cut areas and the laying out of crops of trees on waste ground was often neglected, partly due to the high cost of labour. In order to check the rapid decrease of the Dutch forest area, an Emergency Forest Act, 1917, came into operation, by which the execution of the provisions was entrusted to the Forest Service.

In 1922 this law was replaced by the Forest Act, 1922. In 1928 a Scenery law was enacted, by which estate-owners could get a considerable tax-reduction if they kept to given directives. The Forest Service was charged with the supervision of the observance of this law.

The outbreak of the Second World War in 1939 made it necessary again to put the felling of stands and reafforestation under strong State control. This entailed a further increase in the activities of the Forest Service. The laws and by-laws proclaimed for this purpose were like those already mentioned and are discussed in more detail below.

On an extensive scale the Forest Service gives advice to Government institutions, municipalities, and institutions and associations for public benefit. This information may be stray advice for particular cases, or may be long-range advice, as when the State undertakes the higher management of woodlands.

In the latter case a small charge per hectare is levied, whereas expenditure and proceeds are the concern of the owner. As a rule no private forest is taken under regular administration.

In 1937 the State Forest Service was charged with compiling exact statistics for the existing areas of forest and waste land. In 1938 this was enlarged to include all the arable land, pasture, and orchards. These statistics were almost finished in 1942, but for the present they cannot be accepted as absolutely exact on account of the extensive destruction which took place in the Dutch forest area during the German occupation. Much is being done, however, to map out and survey the damage, after which the Netherlands will possess extremely reliable statistics of the use of its soil. Moreover, forest fire statistics are published yearly in co-operation with the Dutch Heath Exploitation Company.

In the domain of forest protection the fighting of the elm disease must be mentioned particularly. Every year officials of the Forest Service seek out and mark affected elms. In compliance with the Order in Council of 19 September 1935, the owner is obliged to cut down and remove the bark from these trees as soon as possible in order to check further spreading of the fungus. Yearly 20,000 to 40,000 trees are marked in this way.

A separate department under the guidance of a forest officer in general service is engaged on the care of road-side plantations and scenery. There is also a department which arranges the supply of seed and nursery-plants.

In 1944 an organization was instituted to draw up working-plans for the forest areas under the State Forest Service.

The care of the scenery and national parks consigned to the Forest Service is dealt with in more detail below.

Finally, general instruction and the spreading of silvicultural knowledge are carried on. For that purpose pamphlets and wall-pictures about noxious insects and fungi, and treatises on silvicultural themes, are published. There is also a forest-film available, whilst the forestry museum, closed temporarily owing to the war but normally located in the building of the State Forest Service, draws many visitors.

An important contribution to scientific silviculture will be the institution of a

National Arboretum. Plans for this are in preparation, but it has not yet been possible to carry them out, owing to the difficulties of recent years.

Afforestation.

At the time of the institution of the State Forest Service an area of about 13,300 ha., mainly of waste land and with but few forests, came into its possession.

In the course of years this area was gradually enlarged by tracts destined for afforestation, and occasionally by existing forests, as the following schedule shows:

Year (1 Jan.)	*Area*	*Year (1 Jan.)*	*Area*
	ha.		ha.
1900	13,316	1925	40,716
1905	14,396	1930	36,100
1910	18,994	1935	46,837
1915	24,536	1940	58,241
1920	28,728	1943	61,279

During the years after the First World War the area falling under the Forest Service increased very much through the purchase of vast heath-lands in the province of Drenthe. This was in 1922 and 1923, with the object of fighting unemployment; and it was repeated during the period of unemployment which began in 1931. The schedule below shows what the Forest Service has done for the extension of the forest area.

The State's interest in reclaiming waste ground about 1900 extended to both municipal and State land. Many municipalities, especially in the south of the country, possessed extensive heaths which were very suitable for afforestation. Want of interest and expert staff, and financial difficulties, meant that but few woods were laid out, and in many cases even these were tended very badly.

In order to put an end to this, and to promote a permanent municipal forest property, a regulation was made by Order of Council of 27th July 1907, no. 76, under which technical and financial help can be rendered by the Government to municipalities for the afforestation of their waste ground. Later on this help was extended to institutions and associations for public benefit, provided that they possessed an area of waste land sufficiently continuous.

The financial support is given as an interest-free loan to be refunded within 50 years, up to 80 per cent. of the cost of afforestation, subject to a maximum of 190 guilders per hectare.

The technical help is generally given free of charge. On the 1st of January 1943, 58 municipalities and 1 association for public benefit were making use of this form of State aid. An area of 18,000 ha. had been planned, and on 15,200 ha. the afforestation had been completed. Of these afforestation schemes 51 are situated in the provinces of North Brabant and Limburg.

After the completion of the afforestation the young crop remains under the supervision of the Forest Service. For this a small fee per ha. per year is levied.

The following table shows the total area of waste ground afforested by or with the aid of the Forest Service in the course of the last 20 years.

Waste ground afforested

Year	By the State Forest Service	By the municipalities, with interest-free loans	Total area
	ha.	ha.	ha.
1920–4	2,737	3,010	5,747
1925–9	3,218	3,763	6,981
1930–4	3,915	3,210	7,125
1935–9	4,804	2,343	7,147

The extent of forest planted on waste ground by private persons is of minor importance at present; on the other hand, about 400 ha. of forest are cleared annually for the laying out of arable land and pasture. Moreover, a certain amount of forest is not replanted after being felled. If the State did not promote the afforestation of waste ground, the forest area would decrease instead of increasing slowly as at present.

Organization of the Forest Service.

The State Forest Service falls under the Department of Agriculture, Fishery, and Food Supply. At the head is a Director who is assisted by three Inspectors. They have their headquarters in the head office at Utrecht. The various forests are organized by districts under the command of district officers.

At present there are 15 districts in the Netherlands. Their size varies widely. A normal district includes about 6,000 to 13,000 ha. Some, however, are considerably smaller and include only or principally the administration of municipal and other forests.

Most district officers are aided in their work by a young assistant officer. The district is subdivided into a number of ranges, each under a forester who is charged with the day-to-day control of the forest work carried out by the foremen and labourers. Besides these officials of the district service, forest officers on general duties are employed at the head office at Utrecht.

THE PRESENT-DAY METHODS OF AFFORESTATION OF WASTE GROUND AND THE TENDING OF WOODS.

At the beginning of the nineteenth century the trees found in the Netherlands were almost exclusively broad-leaved species. They could be considered in part as a survival of the prehistoric primeval forest. From early in the nineteenth century Scots pine has gained ground. This species of tree appeared to be particularly suitable for the afforestation of waste ground. In the beginning pine woods were laid out by sowing, and mostly without preparation of the soil. By degrees sowing was replaced by planting after deep tillage. Generally, there was no mixture with other species of trees. As soon as the stems were just big enough for mining timber (at the age of 35–45 years) the forests were usually cut, after which the soil was planted again with pines of 1 or 2 years of age. Not much attention was given to thinning.

Since about 1900 silviculture in the Netherlands has taken a better course. A good start was given to it by the silviculturist A. J. van Schermbeek, who was employed in the forest district 'Breda' about 1889–1900. After that he taught till his death in 1915 at the then Higher School for Agriculture, Horticulture, and Silviculture (now the Agricultural University) at Wageningen. He fought against the continued culture of Scots pine in pure stands. He also called attention to the vital connexion between the soil and the standing crop. Further he pointed out that the yield capacity of the soil in silviculture is a varying factor, and that it is one of the first duties of the silviculturist to raise the yield as high as possible through the correct choice of method of treatment, composition of crop, and tending. He tried to gain his object, among other things by bringing broad-leaved trees into the existing crops of pines (underplanting) and by mixture of species at the time of laying out the crops. Underplanting has for its principal object the improvement of the soil on behalf of the existing and future forest, and sometimes the gradual regeneration of the principal crop by means of a lower story. Van Schermbeek rightly saw in the waste of humus an important criterion for judging the condition of a soil. At the start these views met with much opposition, but gradually the ideas, new for the Netherlands, gained more appreciation, and now they enjoy general acknowledgement among scientific silviculturists.

Tending and Regeneration of Forests.

The modern tending of forests attaches the greatest value to an efficient thinning. By taking away the cumbersome superfluous trees, the better shaped boles are helped, and the overtopped trees can be retained as a secondary stand. Generally the condition of the soil of the older pinewoods is unfavourable. Under the needle litter is as a rule a more or less thick layer of indigestible humus, which promotes the leaching of the soil. Any existing vegetation on such soil is generally composed of species of moss (*Hypnum*, *Dicranum*) or of bilberries (*Vaccinium myrtillus*), and sometimes cowberries (*Vaccinium vitis-idaea*). Under later pine crops this condition of the soil is often still more unfavourable.

For the improvement of the soil the trend is more and more to underplanting or undersowing with species of trees whose litter decays better than that of Scots pine. If the improving of the soil is the only objective, then red oak (*Quercus borealis*), American blackcherry (*Prunus serotina*), beech (*Fagus sylvatica*), sweet chestnut (*Castanea sativa*), and the like are chiefly used. If at the same time the regeneration of the standing crop is desired, then the common oak and various species of shade-bearing conifers are used.

In order to promote the first growth, some artificial manure is often administered. After the clear felling of the forest sometimes lupin is cultivated, for the improvement of soils poor in humus through removal of forest litter. In reafforestation major use is usually made of Scots pine, because this tolerant species, which yields well in all the local conditions, promises the best financial results.

More and more the aim is a mixture of pines with soil-improving species, especially broad-leaved trees. For this the red oak (*Quercus borealis*) and the

common oak (*Quercus robur*) are often used. Reafforestation is usually by planting, occasionally by sowing.

Afforestation of Heath.

Heaths are of different kinds in the Netherlands. Those in the eastern part of the province of Drenthe (de Hondsrug) consist of a kernel of preglacial sand, almost entirely covered with glacial sand, with many erratic blocks. This soil is comparatively fertile. In the remainder of Drenthe peat-moor is found in many places. Often the soil has been leached and is poor. Locally boulder-clay is found. The altitude varies between 10 and 28 m. above sea-level.

On the Veluwe and in the province of Utrecht the heath is mostly at a higher level (20–80 m. above sea-level) and hilly. The sand is chiefly preglacial, with gravel. Locally bank-formation is found. Generally the soil is dry because of the low water-table.

The heath region of North Brabant is flat country and the altitude varies from 10 to 30 m. above sea-level. The sand is preglacial, fine-grained, with locally a little gravel. Sometimes loam coats are found, and generally draining is necessary.

For the afforestation of heath-land tillage usually consists of ploughing. Where a hard pan is found in the soil at such a depth that it can be removed with the plough, this is done. Some ground requires only shallow ploughing. Sometimes the ground below the furrow is loosened with a subsoil plough. Before ploughing the heath sods are crumbled with a disk-harrow if necessary. During the years when unemployment was rife the preparation of the soil was mainly by digging, in order to set more labourers to work. If the ground wants draining, the necessary ditches and cross-ditches are dug. When the prepared soil is of poor quality, it is planted as a rule with 1- or 2-year-old, lined-out pines or sown with Scots pine seed, generally mixed with broad-leaved trees. In the province of Drenthe, however, where the Scots pine often suffers from needle-shedding disease (*Lophodermium pinastri*) in its youth, and also elsewhere, the better quality ground is often afforested with Japanese larch (*Larix leptolepis*), Douglas fir (*Pseudotsuga douglasii*), oak (*Quercus robur* or *Quercus petraea*), Sitka spruce (*Picea sitchensis*), or Norway spruce (*Picea abies*), sometimes after preparation through the cultivation of lupins. The ground which is to be afforested is divided into plots of 6–8 ha. by roads and unplanted strips of 8–10 m. wide, later used for transporting timber. Often belts of birches, red oaks, black cherries, black locust (*Robinia pseudacacia*), &c., are laid out along these roads to decrease the danger from fire, which in a large area of young conifers is considerable.

For sheltering and soil improvement the ruling species of tree can be mixed with white alder (*Alnus incana*) or birch (*Betula* sp.) and perennial lupins (*Lupinus angustifolia*).

Afforestation of Shifting Sand.

Shifting sand must be fixed before it is afforested, and often tillage precedes the planting. In any case the low parts, where the sand has been blown away, are

worked over with the plough or the shovel. After this tillage the ground is covered with a thin layer of mown heather. To prevent the blowing away of the heather, shovelfuls of sand are thrown down at regular intervals. As a rule the growth on places where the sand has been blown away is much poorer than on the hills where the sand has piled up.

For planting, Scots pine, Austrian pine, Corsican pine, and maritime pine (*Pinus pinaster*) are used. Generally the shifting sand plantations meet with many troubles through drought and needle shedding disease in their early years. The nearer the plantation comes to closing the canopy, the more the growth increases. Where it is possible, broad-leaved trees are mixed with the conifers.

Afforestation of Dunes.

In the afforestation of dunes it is necessary to overcome not only the difficulties of the infertile moving sand, as in the case of the shifting sands, but also the effect of salt sea winds. By 1863 the first experiments took place near Schoorl in the province of North Holland. The existing growth of all sorts of grasses, particularly the *Corynephorus*, may seriously impede the first growing period of the young wood. Usually the more vegetation there is, the deeper the tillage has to be.

After tillage the ground has to be fixed again, which is done either by planting beech grass (*Ammophila arenaria*) or by covering the ground with mown heather.

In very dry soils the seedling, when planted, is given a soaked lump of peat which serves as a water-tank.

The most suitable tree for dune afforestation is Austrian pine. In the better and more sheltered places Corsican pine and Sitka spruce grow well, too. Mountain pine (*Pinus montana*) and maritime pine (*Pinus pinaster*) may serve well here and there. In moist places broad-leaved species such as oak, poplar, and beech are used.

The edges of the forest which have to serve as a wind screen are of particular importance. For this, alder (*Alnus glutinosa* and *Alnus incana*), hawthorn (*Crataegus oxyacantha*), white poplar (*Populus alba*), and some species of birch and willow are the most suitable trees.

INSTRUCTION AND RESEARCH.

Forest officers are trained in the Silvicultural Department of the Agricultural University at Wageningen. The course lasts 5 to 6 years and leads to the degree of agricultural engineer.

The Dutch Heath Exploitation Company gives a forestry training directly designed for their practical work. This is divided into two parts. The courses last two winters, the summers being spent on practical work. Though these courses show good results, there is a lack of opportunity to train the lower forest staff.

Research was carried on at the State Forestry Experimental Station at Wageningen from 1919. It closed in 1928 for financial reasons, but its activities have been continued by the Institute for Silvicultural Research in the same town, which Institute is a branch of the Agricultural University.

Noteworthy activities of this Institution include research on the best origin of

Douglas fir seed for the Netherlands, on the properties of the timber from exotic trees grown in the Netherlands, and on the problem of the decomposition of forest litter.

The State forest, 'Oostereng', situated near Wageningen, is at the disposal of this Institution for experiments.

At the Agricultural University silvicultural research is carried on in the Laboratory for Genetics (cross-breeding of poplars) and the Institution for Phytopathology. Here the diseases and enemies of forest trees are studied, as also at the Phytopathological laboratory, 'Willie Commelin Scholten', at Baarn. Under the direction of the Elm Disease Committee the well-known research into the cause of the elm disease has been carried out, and now that it is completed, a search is in progress for species and varieties of elms resistant to the disease.

The Biological Laboratory at Hoenderloo (province of Gelderland) is engaged upon fighting insect pests and examining animals harmful to silviculture. For this there is a travelling laboratory available to carry out research on the spot, in case of a threatened plague.

The results of these researches appear in the *Communications of the Agricultural University* (*Mededeelingen der Landbouw Hoogeschool*), the *Dutch Silvicultural Magazine* (*Nederlandsch Boschbouwtijdschrift*), the *Magazine of the Dutch Heath Exploitation Company* (*Tijdschrift der Nederlandsche Heidemaatschappij*) and the *Magazine for Plant Diseases* (*Tijdschrift over Plantenziekten*).

DUTCH FOREST LEGISLATION.

During the First World War the necessity of radical measures for Dutch forest conservation became evident. Hence in 1917 the Emergency Forest Act was brought into existence. By virtue of this Act the Minister of Agriculture could prohibit or permit only conditionally the felling of forests and other standing crops to supply firewood, mining-timber, piles or industrial timber; or for aesthetic reasons. No compensation for possible loss to the proprietor or rightful owner of the timber was payable under this prohibition.

In place of the above Act a Forest Act was proclaimed in 1922. This included measures to minimize damage by insects and fungi, to reduce the danger of fires caused by railways and tramways, and to preserve beautiful scenery where it was threatened by the felling of trees or forests. Further, the Forest Act of 1922 included provision for technical and financial help—the latter in the shape of interest-free loans—to public bodies, as well as to associations and institutions for public benefit. It also ensured that the administration of forests and standing crops belonging to municipalities and other public bodies, and also to associations and institutions for public benefit, should be subject to the State, in that the owners were required to give notice beforehand to the State Forest Service of all proposed fellings.

The important Clause 12 of the Forest Act makes possible the giving of an annual financial contribution to municipalities, associations, and institutions for public benefit for the maintenance of beautiful scenery involving forests and other standing crops. In recent years a sum of almost 100,000 guilders has been paid

out for this, yearly. The State Forest Service is charged with the supervision of the forests for which such contributions are given by the State.

Finally the Forest Act provides for expropriation of forests and other standing crops on behalf of the State, a municipality, or an association for the preservation of beautiful scenery.

A modification in the State Income Tax Act of 1926 laid down that receipts from forest management, except coppice-exploitation, do not fall under assessable income. In respect of some other taxes, also, concessions are granted in favour of silviculture.

Of great importance to the beautiful scenery of the country are the estates with their avenues, forests, parks, farms, &c. The recognition of this led to the Scenery Act, 1928, in which some taxes on estates were modified so as to encourage the maintenance of beautiful scenery.

When a proprietor binds himself to maintenance and proper administration, he gets considerable relief in respect of property tax, which advantage is doubled if he throws open his estate to the public in accordance with an officially approved arrangement. Such an arrangement under the Scenery Act is quite voluntary. Notice must be given of intended fellings and thinnings to the Director of the State Forest Service, who must approve these fellings, and also see that the estate maintains its character in accordance with the law.

Numerous estate proprietors avail themselves of these arrangements. In 1945 483 estates, with a total area of over 72,000 ha. were so managed, and 58,000 ha. of these had been opened to the public.

The outbreak of the Second World War in 1939 and the threatening dearth of timber again compelled drastic intervention by the authorities, resulting in the Land Production Act, 1939. Fellings of forests and scattered trees required a written licence from the Director of the State Forest Service; and the Director could also order the felling of forests and trees in order to meet the want of timber.

In 1943 this law was replaced by a State Supervision decree, under which all forests, standing crops, and tree nurseries were put under State supervision. The proprietor continues administering his forest under this regulation, but the State determines every year how much wood he must fell.

Also reafforestation can be prescribed, and without a licence nothing may be felled. A revision of this decree is under preparation.

During the German occupation a great part of the Dutch forests was destroyed. Measures will be taken on behalf of the Government to reafforest these areas as soon as possible.

In the matter of beautiful scenery it is to be expected that Government care will be extended. The ever-increasing population (each year a good 100,000 more inhabitants) and traffic necessitate caring for the rural beauty to which almost all forests contribute.

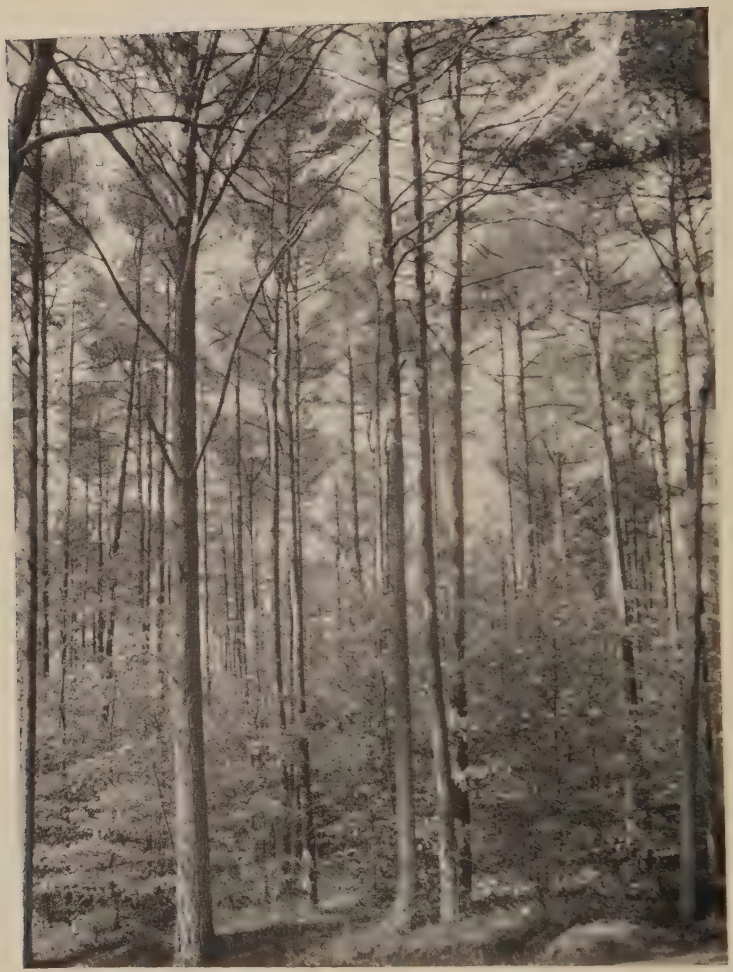
THE STATE FOREST SERVICE AND THE SCENERY.

The State Forest Service has been charged in large measure with the care of Dutch scenery and landscape. Besides the above-mentioned supervision of estates,

Afforestation of the dunes near Schoorl, forest-district Alkmaar. Austrian pines, 40 years old. (*Pinus nigra* var *austriaca* Aschers et Graebn.)

4 years old oak, sown at site. 128 years old oak forest in background (*Quercus robur* L.). Liesbosch, forest-district Breda

PLATE I



Scots pine (*Pinus sylvestris* L.) about 70 years old, underplanted with beech (*Fagus sylvatica* L.) about 15 years old (planted as 3 year olds). Near Dorst, forest-district Breda

PLATE II

under the Scenery Act, 1928, the following considerations are kept in view. Though by or with the aid of the Forest Service much waste ground has been reclaimed to forest, the Service is quite aware of the need to preserve some areas in an untouched condition, where they are of particular importance from a scientific (botanical, zoological, geological, or archaeological) point of view or on account of beautiful scenery. Important areas falling under the Forest Service are consequently excluded from afforestation. These exclusions comprise shifting sands, heaths, fens, and dunes, and have an area of over 10,000 ha. The most extensive, totalling 7,600 ha., are the well-known bird breeding-grounds on the islands of Texel and Terschelling in the North Sea.

Everything is done in the course of the afforestation of municipal waste land with the help of the State Forest Service to maintain interesting local areas. In this work the municipalities co-operate well.

Besides the exclusions which remain untouched there are old broad-leaved and coniferous forests whose conservation is of the greatest importance to the scenery. Unfortunately many of these forests have been destroyed to a great extent or entirely by the Germans during the occupation.

In the selection and conservation of nature reserves the Forest Service is advised by a committee of experts, formed at the request of this Service.

Close co-operation is maintained with the other institutions concerned with nature reserves in the country, viz. the Association for the Conservation of Nature Reserves, and the provincial associations. The Forest Service often advises the National Service for Town and Country Planning and is represented on various committees to this end.

In order to survey all the land in the country whose preservation in untouched condition is of importance for science or scenery the Forest Service has almost finished a stocktaking on a plant-sociological basis.

Much advice given by the Forest Service refers to the conservation of beautiful scenery, especially in planting along the highways and provincial and municipal roads. These roads are of great importance to the beauty of the landscape, and aesthetic values have to be taken into account.

In the execution of great works, such as land planning or the regulation of watercourses, &c., advice is given by the State Forest Service to guard against permanent injury to beautiful scenery.

THE BOWMONT NORWAY SPRUCE SAMPLE PLOTS (1930–45)

(*Picea abies* Karst. syn *P. excelsa* Link)

By F. C. HUMMEL
(*Forestry Commission*)

THE Bowmont sample plots were established in 1930 with the object of investigating the effect of different thinning grades on the increment and general development of the growing stock of Norway spruce. This experiment is of particular interest because it is the only one in Great Britain—and there are probably not many in other countries—where it has been practicable to replicate each of 4 thinning treatments 4 times on one site, giving a total of 16 sample plots which are laid out in the form of a Latin square. With this layout and degree of replication it is possible to estimate with some degree of precision to what extent differences between plots are actually caused by differences of treatment and to what extent they are due to other factors, such as slight fertility gradients within the site.

Mr. J. A. B. Macdonald established the plots in 1930. He has cared for them ever since and has described their early history in two papers (2) (3). The present paper describes the subsequent history of the plots as revealed by the periodic remeasurements and is in the nature of an interim report, because it would obviously be premature to draw final conclusions before the stand reaches maturity.

SITE AND LAYOUT.

Bowmont Forest is situated near Kelso in the county of Roxburgh, Scotland, and forms part of the estate of the Duke of Roxburghe. The forest occupies a broad and almost level ridge-top between the Teviot on the west and Kersknowe on the east. The elevation is about 550 feet above sea-level, and the Norway spruce plantation lies on gently sloping ground just to the east of the highest point of the ridge. The plantation is sheltered to some extent by slightly higher ground in the west and south. In the other directions there is no higher ground for several miles, but some degree of shelter is afforded by adjoining plantations. The soil is a fine sandy loam overlying Old Red Sandstone.

The plots were established, measured, and thinned in 1930, when the plantation was 20 years old. Subsequently the plots were remeasured and thinned in 1935, 1940, and 1945. At establishment height growth was uniform; the average height of the 100 largest trees per acre in all the plots was between 24 and 25 feet, and the mean crop height between 21 feet and 22½ feet. This places the plots in Quality Class III, according to the British yield tables for Norway spruce. The plots were also very similar in the number of trees and in the basal area per acre, as is shown

in Table I. In spite of this similarity the average volumes of the plots assigned at random to the various treatments differed between 782 cu. ft. in the D grade plots and 925 cu. ft. in the B grade plots. The reason for this considerable difference lies probably in the fact that these volumes are not total volumes but timber volumes down to $2\frac{3}{8}$ inches quarter-girth, and the breast-height girth of the majority of the trees was either just above or below that girth limit in 1930. A very slight difference in girth would thus produce a considerable difference in timber volume.

The 16 plots, each a square with an area of 0·1 acre, were laid out in 4 rows of 4 plots and were separated from one another by buffer strips 28 feet wide. The outer surround varies in width between 33 and 100 feet. Both the small size of the individual plots and the narrow buffer strips between them are open to criticism; but as the extent of the experiment was strictly limited by the area of the site, it was a matter of choosing between replicated small plots or medium-sized plots without replication. The fact that statistically significant differences between treatments have been obtained shows that the choice of replicated small plots was correct. Without replication no statistical treatment would have been possible, and the interpretation of results would have been largely a matter of personal opinion.

It should be mentioned here that the layout was practicable only because the spacing of the rows and of the trees within the rows was exceptionally regular, thanks to the skill of Mr. George Leven, the forester who had supervised the planting 35 years before. He has always been most helpful and is still in charge of the area.

NOTES ON COMPUTATIONS.

Girths are given in inches quarter-girth (= $\frac{1}{4}$ true girth), basal areas and volumes in sq. ft. and cu. ft. quarter-girth (= true measure × 0·7855). All volumes refer to under-bark timber volume down to an over-bark diameter of 3 inches. All figures for number of trees, basal areas, and volume, unless otherwise stated, represent the mean values of the 4 plots in each treatment and refer to an area of 1 acre. 'Mean height' is the mean height of the main crop as calculated by Lorey's formula (1). 'Top height' is the height corresponding to the mean basal area of the 100 largest trees per acre. The terms 'top girth' and 'top form factor', in the same way as top height, are used to denote the means of the 100 largest trees per acre. The term 'main crop' describes the growing stock after thinnings. The factors height, girth, form factor, and volume per tree have been considered separately for the main crop and for the 100 largest trees per acre. The means for the main crop change not only by the growth of the crop but also by the elimination of trees in thinnings. An example of this latter effect is provided by the crop mean basal area before and after thinnings in the D and L.C. grade plots in 1930. In both sets of plots the crop mean basal area before thinning was 0·044 sq. ft. per tree. After thinning the D grade plots had a crop mean basal area of 0·053 sq. ft. per tree, which represents an increase of about 20 per cent., and the L.C. grade one of 0·041 sq. ft. per tree, which represents a decrease of about 7 per cent.

On the other hand, very few of the 100 largest trees per acre are removed under any thinning régime. Increases in height and girth of these 100 trees are therefore almost wholly due to growth, and differences in the rate of increase clearly indicate the effect of treatment.

TREATMENTS.

The four standard thinning grades normally used in sample plot work by the Forestry Commission were applied:

B grade = a light low thinning.

C „ = a moderately heavy low thinning.

D „ = a heavy low thinning.

L.C. „ = a light crown thinning. In practice this is not quite as light as the name implies, and the volume of growing stock which is left after it is nearly as low as that left after a D grade thinning. More detailed definitions of the above thinning grades are given by James Macdonald (1).

Some idea of the severity of each of the thinning grades may be obtained by comparing the number of trees, basal area, and volume of the growing stock that was left after each thinning. This comparison is given in Table I.

The figures in the table should be studied in conjunction with photographs which were taken by Mr. W. P. Thomson after the thinnings in 1945. These photographs illustrate, more clearly and vividly than figures alone, the contrasts between the thinning grades in their effect on the appearance of the remaining crop.

In the heavier thinning grades, and particularly in the D grade plots, the main crop basal area was sometimes reduced to less than what it was after the previous thinning. This does not indicate that the officer marking the thinnings has been inconsistent in interpreting the thinning grades as defined by the British code of sample plot procedure, because this code depends entirely on the tree classification and, in contrast to some continental codes, does not prescribe any basal area check. Whether or not such a check would be desirable is a debatable point.

RESULTS.

Total volume production, including thinnings.

Preliminary examination of the total volumes produced up to 1945 showed little indication of effects of treatments. However, these volumes were markedly correlated with the volumes of the same plots in 1930, and by means of the covariance analysis the precision of the comparisons could be much increased. This covariance analysis was used to adjust the 1945 volumes for inequalities in the plots in 1930. The B grade plots were appreciably higher in volume than the others in 1930, and the adjustment therefore reduced the 1945 B grade volumes relative to the others. After adjustment the average volumes for the D grade and L.C. grade plots is significantly higher than the average for the B and C grade

3355-33 D

TABLE I. *Main Crop after Thinning*

Thinning grade	1930						1935			1940			1945		
	Age 20 years						Age 25 years			Age 30 years			Age 35 years		
	Before thinning			After thinning			After thinning			After thinning			After thinning		
	No. of trees	Basal area (sq. ft.)	Volume (cu. ft.)	No. of trees	Basal area (sq. ft.)	Volume (cu. ft.)	No. of trees	Basal area (sq. ft.)	Volume (cu. ft.)	No. of trees	Basal area (sq. ft.)	Volume (cu. ft.)	No. of trees	Basal area (sq. ft.)	Volume (cu. ft.)
B . .	3,022	137	925	2,872	135	923	2,260	160	1,678	1,783	179	2,449	1,515	192	3,276
C . .	3,064	136	822	2,417	124	814	1,840	144	1,608	1,507	164	2,377	1,015	149	2,558
D . .	3,032	133	782	1,942	104	688	1,017	95	1,139	632	104	1,775	387	97	1,843
L.C. .	3,050	134	803	2,655	110	600	2,020	114	1,011	1,448	123	1,630	938	124	2,045

plots. In addition, C grade volumes are appreciably though not significantly higher than B grade volumes and D appreciably higher than L.C. grade volumes. These results are summarized in Table II.

TABLE II. *Total Volume Production (cu. ft.)*

Thinning grade	*Total volume production up to*			
	1930	*1945 unadjusted*	*1945 adjusted*	
B . .	925	3,462	3,219	±103·0
C . .	822	3,450	3,478	
D . .	782	3,895	4,030	
L.C. .	803	3,667	3,747	
Mean .	..	..	3,619	

Periodic mean annual volume increment.

Examination of the periodic mean annual volume increments shows that treatment differences have not been uniform in the three periods under review. This is indicated in Table III.

TABLE III. *Periodic Mean Annual Volume Increment (cu. ft.)*

Thinning grade	*Period*					*Mean*
	1930–5		*1935–40*		*1940–5*	
B . .	152	±8·2	167	±8·9	189	169
C . .	173		190		163	175
D . .	179		247		196	207
L.C. .	159		217		197	191
Mean .	166		205		186	..

(*Note:* Differences between treatments of more than 3·4 times the standard error are significant at the 5 per cent. probability level.)

During the first period B and L.C. grade increments were very similar and appreciably, but not significantly, less than C and D grade increments, which were also similar. During the second period the D grade volume increment was significantly the highest at 247 cu. ft. per annum. The L.C. grade with 217 cu. ft. came second and was followed by the C and B grades with 190 and 167 cu. ft., respectively. The L.C. grade increment was significantly higher than the B grade increment, but the differences between L.C. and C, and C and B grades, although appreciable, were not significant. During the third period B, D, and L.C. grade increments were very similar, with 189 cu. ft., 196 cu. ft., and 197 cu. ft. per year. C grade increment was considerably, but not significantly, lower at 163 cu. ft. per year.

Increment varied significantly between the three periods. Taking the means of all treatments combined, it was about 20 per cent. higher during the second

period than during the first; and during the third period it was intermediate between the first and second periods. The same trend was shown by the D and L.C. grade plots. In the B and C grade plots there were no significant differences between periods, and such differences as there were did not entirely follow the trend of the other two grades. Thus, in the B grade, increment was higher during the third period than during the second, and in the C grade it was slightly lower in the third period than in the first.

Periodic mean annual basal area increment.

Periodic mean annual basal area increments are given in Table IV. The treatment differences were much more pronounced than for periodic mean annual volume increment, and they were consistent throughout the three periods.

TABLE IV. *Periodic Mean Annual Basal Area Increment (sq. ft.)*

Thinning grade	*Periodic mean annual basal area increment*			*Mean*
	1930–5	*1935–40*	*1940–5*	
B	7·4	7·3	5·4	6·70
C	7·9	7·8	6·0	7·23
D	8·4	9·7	8·4	8·83
L.C.	8·3	9·3	7·8	8·47
Mean	8·0	8·5	6·9	
	±0·14	±0·16	±0·15	

(*Note:* Differences between treatments of more than 3·4 times the standard error are significant at the 5 per cent. probability level.)

During each period D grade increments were largest, and the other treatments followed in the sequence L.C., C, and B. The differences were all either significant or nearly significant, except during the first period, when L.C. grade increment was only slightly less than D grade increment. During the second and third periods the treatments fell clearly into two groups, the D and L.C. grades being far superior to the other two.

In the D and L.C. grades increment was very similar in the first and third periods and significantly higher in the second. In the other two treatments increments were very similar during the first and second periods and significantly lower in the third. In Figure 1 the periodic mean annual basal area increments for each period have been plotted over the main crop basal area at the beginning of the period, and it is apparent from this figure that basal area increment was very closely correlated with main crop basal area, and that, for any given main crop basal area, increment was almost identical during the first and third periods and very much greater during the second.

Height.

Table V shows that height growth was very similar in all thinning grades and uniform throughout the three periods. Top heights in 1930 were all between 24 and 25 feet, in 1935 between 30¼ and 31 feet, in 1940 between 36 and 37 feet, and

TABLE V. *Top Heights and Mean Heights (feet)*

Thinning grade	*1930*		*1935*		*1940*		*1945*	
	Mean height	*Mean height of 100 largest trees*	*Mean height*	*Mean height of 100 largest trees*	*Mean height*	*Mean height of 100 largest trees*	*Mean height*	*Mean height of 100 largest trees*
B. .	22½	25	29	31	34½	36½	39½	42
C. .	22	24	28½	30½	35	36	40½	41½
D. .	22	24½	29½	30½	36	37	42	42½
L.C. .	21	25	28	30½	33	36	39	42

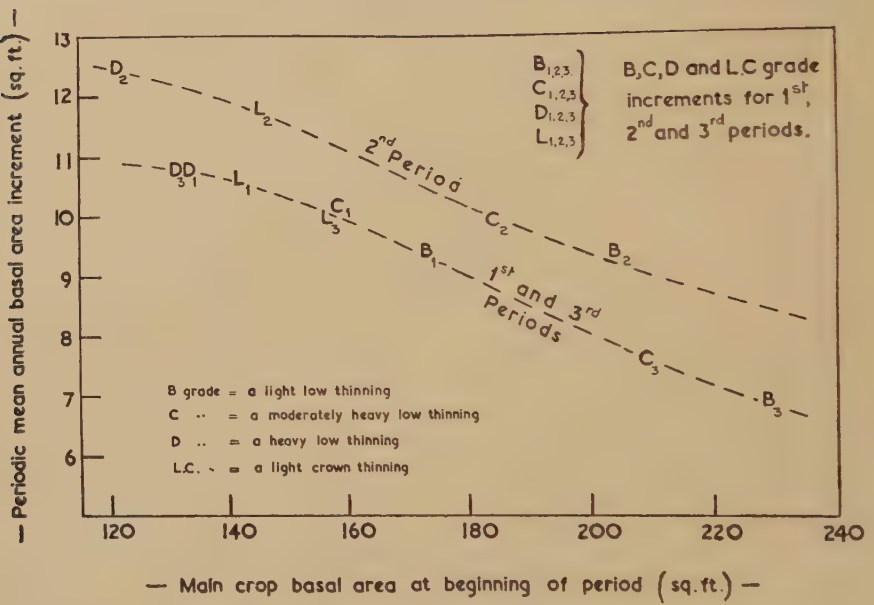


FIG. 1. The relation between periodic mean annual basal area increment and main crop basal area.

in 1945 between 41½ and 42½ feet. The average increase in each treatment is thus between 5 and 6 feet during each of the three 5-year periods. Mean crop heights were between 21 and 22½ feet in 1930, and they increased at approximately the same rate as top height, but there was a tendency for the difference between crop mean height and top height to decrease, the rate of decrease being proportionate to the number of small stems eliminated in thinnings. Thus in the D grade the difference was reduced from 2½ feet in 1930 to ½ foot in 1945, and in the B grade it remained constant at between 2½ and 3 feet throughout the three periods.

Girth.

Girth, in contrast to height, was very strongly affected by treatment, as is shown in Table VI. Crop mean girths in 1930 were very similar in all treatments and

varied between 2⅜ inches and 2¾ inches quarter-girth. In 1945 D grade had a crop mean girth of 6 inches quarter-girth, and this was significantly higher than the mean girths of the other treatments, which then varied between 4¼ and 4⅝ inches quarter-girth.

Top girths varied between 3¾ and 3⅞ inches in 1930. In 1945 the treatments fell into two distinct groups: B and C grades with top girths of 5¾ and 5⅞ inches quarter-girth, and D and L.C. grades with top girths of 6¾ and 6⅞ inches quarter-girth. It is worth noting that the L.C. grade was similar to the B grade in the development of crop mean girth and similar to the D grade in the development of top girth.

TABLE VI. *Mean Quarter-girth of Main Crop, and of 100 Largest Trees per Acre (inches quarter-girth)*

	1930 *After thinning*		1935 *After thinning*		1940 *After thinning*		1945 *After thinning*	
Thinning grade	*Mean Q.-G. (in.)*	*Mean Q.-G. of 100 largest trees (in.)*	*Mean Q.-G. (in.)*	*Mean Q.-G. of 100 largest trees (in.)*	*Mean Q.-G. (in.)*	*Mean Q.-G. of 100 largest trees (in.)*	*Mean Q.-G. (in.)*	*Mean Q.-G. of 100 largest trees (in.)*
B . .	2½	3⅞	3½	4⅝	3¾	5⅜	4¼	5⅞
C . .	2¾	3⅞	3⅜	4⅝	4	5¼	4⅝	5¾
D . .	2¾	3¾	3⅝	4⅝	4⅞	5¾	6	6¾
L.C. .	2⅜	3¾	2⅞	4⅝	3½	5¾	4⅜	6⅞

Form factors.

The values for both main crop and top form factors which are given in Table VII refer to timber volumes and not to total volumes. When girth is small the timber form factor increases rapidly with girth, even if the actual form of a tree remains constant. As the Bowmont plots had only just reached the lowest timber girth of 2⅜ inches in 1930, differences and changes in the timber form factor during the 15 years under review reflect differences and changes in girth rather than in form. It is therefore not possible to deduce from the present data whether and how treatment has affected form. This could only have been done by using

TABLE VII. *Form Factors*

	1930 *Form factor*		1935 *Form factor*		1940 *Form factor*		1945 *Form factor*	
Thinning grade	*Main crop*	*100 largest trees*	*Main crop*	*100 largest trees*	*Main crop*	*100 largest trees*	*Main crop*	*100 largest trees*
B . .	0·303	0·386	0·364	0·422	0·400	0·436	0·431	0·449
C . .	0·301	0·419	0·391	0·437	0·415	0·449	0·429	0·451
D . .	0·299	0·398	0·406	0·445	0·480	0·463	0·453	0·434
L.C. .	0·256	0·409	0·319	0·442	0·407	0·455	0·428	0·465

form factors which refer to total volume instead of timber volume, and, unfortunately, figures for total volume are not available.

Volume per tree.

Probably the most important effect of treatment has been on the average volume increment per tree. The relevant figures are summarized in Table VIII.

TABLE VIII. *Mean Volume per Tree of Main Crop and of 100 Largest Trees per Acre*

	1930 After thinning		*1935 After thinning*		*1940 After thinning*		*1945 After thinning*		
Thinning grade	*Mean volume (cu. ft.)*	*Mean volume of 100 largest trees (cu. ft.)*	*Mean volume (cu. ft.)*	*Mean volume of 100 largest trees (cu. ft.)*	*Mean volume (cu. ft.)*	*Mean volume of 100 largest trees (cu. ft.)*	*Mean volume (cu. ft.)*	*Mean volume of 100 largest trees (cu. ft.)*	
B . .	0·32	1·35	0·74	2·5	1·37	4·04	2·16	5·59	±0·22
C . .	0·34	1·32	0·87	2·43	1·58	3·97	2·52	5·49	
D . .	0·35	1·26	1·12	2·56	2·81	4·97	4·76	7·47	
L.C. .	0·23	1·23	0·5	2·49	1·13	4·76	2·18	8·15	

After the thinnings in 1930 main crop averages were still very similar in the B, C, and D grades with 0·32, 0·34, and 0·35 cu. ft. per tree. In the L.C. grade it was considerably lower at 0·23 cu. ft. per tree because a considerable number of the larger co-dominants had been removed in the thinnings of that year. In 1945 the average in the D grade was 4·76 cu. ft. per tree, and this was about twice as large as the average of any of the other treatments, which varied between 2·16 and 2·52 cu. ft. per tree.

The development of the 100 largest trees is equally striking. In 1930 the averages in all treatments varied between 1·23 and 1·35 cu. ft. per tree. The big difference between the average volume per tree of the main crop and the average volume of the 100 largest trees in that year is explained by the fact that the volumes are timber volumes and that in 1930 a considerable proportion of the trees had not reached the lowest timber girth of $2\frac{3}{8}$ inches. In 1945 the treatment means for the 100 largest trees fell clearly into two groups; B and C grades with 5·59 and 5·49 cu. ft. per tree, and D and L.C. grades with 7·47 and 8·15 cu. ft. per tree. The differences between the two groups are highly significant. The difference between L.C. and D is appreciable but not quite significant at the 5 per cent. probability level.

Crown per cent.

Crown per cent. is defined as:

$$\frac{\text{total height} - \tfrac{1}{2}(\text{base to lowest living branch} + \text{base to lowest living whorl of branches})}{\text{total height}} \times 100$$

Crown per cent. is thus an index of the depth of crown in relation to the total height of a tree, and high values of crown per cent. correspond to crowns reaching far down the stem.

The arithmetic mean of the crown per cent. of the 32 sample trees for each treatment is taken as the treatment crown per cent. These crown per cent. data are given in Table IX.

TABLE IX. *Crown Per Cent.*

Thinning grade	*Crown per cent.*			
	1930	*1935*	*1940*	*1945*
B . .	Not calculated	48½	34	31
C . .		48	35½	33
D . .		48	40	40½
L.C. .		50	34½	34½

In 1935 the crown per cent. data were similar in all treatments and varied between 48 and 50 per cent.

In 1945 D grade crown per cent. was 40½ per cent., which was considerably higher than the crown per cent. of the L.C., C, and B grades, which were 34½, 33, and 31 per cent. The comparatively low crown per cent. of the L.C. grade was due to the retention in that grade of sub-dominant and suppressed trees which weighted down the average crown per cent. of the crop.

Yield from thinnings.

Table X gives the yield from thinnings, separately for each period and treatment. In 1930 the yield from thinnings was directly proportionate to the quantity and type of trees removed. In that year 1,090 trees, or about 35 per cent. of the total number, were cut out in the D grade, 647 in the C grade, 395 in the L.C. grade, and only 150 in the B grade. In the low thinning grades the average volume of trees removed was very small, owing to the fact that a large proportion of the suppressed and sub-dominant trees had not reached the lowest timber girth of 2⅜ inches quarter-girth, and therefore had no timber volume at all. The average volumes of thinnings in the B, C, and D grades were 0·01, 0·01, and 0·09 cu. ft. per tree. In the L.C. grade the average volume was considerably higher at 0·51 cu. ft. per tree, because only co-dominants and dominants were removed.

In subsequent thinnings the yield was governed not only by the number of trees felled but also by the effect of previous thinnings on the development of the growing stock, and this effect clearly increased with time. In the third and fourth thinning the actual number of trees removed in the D grade was less than in the less severe thinning grades, but the average volume per tree and total volume of thinnings were very much higher. In 1945 the average volume per tree of D grade thinnings was 3·73 cu. ft., which was more than 3 times the average for C and L.C. grade thinnings, and more than 8 times the average for B grade thinnings, these last averaging only 0·44 cu. ft. per tree. The total volume of produce removed

TABLE X. *The Yield from Thinnings*

Thinning grade	1930 Age 20 years				1935 Age 25 years				1940 Age 30 years				1945 Age 35 years			
	No. of trees per acre	*Mean quarter-girth (in.)*	*Q.-G. volume per tree (cu. ft.)*	*Q.-G. volume per acre (cu. ft.)*	*No. of trees per acre*	*Mean quarter-girth (in.)*	*Q.-G. volume per tree (cu. ft.)*	*Q.-G. volume per acre (cu. ft.)*	*No. of trees per acre*	*Mean quarter-girth (in.)*	*Q.-G. volume per tree (cu. ft.)*	*Q.-G. volume per acre (cu. ft.)*	*No. of trees per acre*	*Mean quarter-girth (in.)*	*Q.-G. volume per tree (cu. ft.)*	*Q.-G. volume per acre (cu. ft.)*
B . .	150	$1\frac{3}{8}$	0·01	2	612	$1\frac{5}{8}$	0·01	5	477	$2\frac{1}{4}$	0·13	60	268	$2\frac{3}{4}$	0·44	119
C . .	647	$1\frac{5}{8}$	0·01	8	577	$2\frac{1}{4}$	0·12	71	333	$2\frac{7}{8}$	0·54	180	492	$3\frac{5}{8}$	1·29	633
D . .	1,090	$1\frac{7}{8}$	0·09	94	925	$2\frac{13}{16}$	0·48	446	385	$3\frac{7}{8}$	1·56	600	245	$5\frac{3}{8}$	3·73	913
L.C. . .	395	3	0·51	203	635	$2\frac{15}{16}$	0·60	381	572	3	0·82	467	510	$3\frac{1}{4}$	1·12	572

in the four thinnings combined were: D grade, 2,053 cu. ft.; L.C. grade, 1,623 cu. ft.; C grade, 892 cu. ft.; and B grade, 186 cu. ft.

DISCUSSION.

Total volume production to date has been significantly higher in the D and L.C. grade plots than in the B and C grade ones, but during the most recent 5-year period the B grade plots have put on as much increment as the heavily thinned plots. This does not necessarily mean that the rate of growth of the B grade plots relative to the C and D grade plots has suddenly increased. The apparent increase in B grade increment may be due largely to the fact that until 1940 much of the B grade increment but only a small proportion of D grade increment went into small wood under 3 inches diameter. Such small wood is not considered in volume calculatious, because of its negligible value. By 1940, however, most of the trees, even in the B grade plots, had reached 3 inches diameter and therefore started to produce measurable increment. If this explanation is correct, the differences in increment between treatments are likely to be less in future than they have been in the past; but it is unlikely that the B grade will actually overtake the D grade in rate of volume production. Future remeasurements will provide a final answer on this point. For the present the important fact is that the heavy thinning grades have produced a larger volume to date. There is nothing in the data to suggest that these grades will lose this initial advantage, although there may be some doubt as to whether they will increase it.

The heavy grades have clearly shown their superiority in producing larger-sized trees in a shorter time, while also providing a substantial early return on the invested capital in the form of thinnings. Very fast girth increment admittedly tends to produce coarse timber with large knots, and the sample plot data furnish no information on this point, except indirectly by the value of crown per cent. Of course, the formation of large knots can be prevented by pruning.

Light crown thinnings have not compared unfavourably with low thinnings. The volume of the 100 largest trees per acre is now higher in the L.C. grade than in any other grade, and the yield from thinnings has also been satisfactory. The yield was admittedly 20 per cent. higher by volume in the D grade, but in that grade there are only 387 trees left standing compared with 938 in the L.C. grade. These additional trees, which do not seem to interfere with the growth of the élite stems, may prove beneficial as a soil covering and may perhaps even develop into a second story with an appreciable volume of useful timber. Even if this development does not take place, the results to date indicate that the retention of the suppressed and sub-dominant trees in the L.C. grade does no harm. It is useful to bear this in mind when there is no ready market for small thinnings.

Grateful acknowledgement is made to Mr. W. H. Guillebaud, Director of Research and Education, Forestry Commission, for permission to utilize the results of his analysis of increment for the periods 1930–5 and 1935–40; and also to Dr. D. J. Finney, Lecturer in Statistics, Oxford University, who supplied the covariance analysis for total volume production, and notes thereon, and very kindly advised on some other aspects of the work. Messrs. James and J. A. B.

Macdonald, W. P. Thomson, and A. M. Mackenzie, all past sample plot officers of the Forestry Commission, suggested improvements to the original draft of this paper. Mr. Thomson also supplied the photographs, as well as some notes on the history and layout of the plots. The members of the English sample plot party, Messrs. Irvine, Jeffers, and Christie, spent a considerable amount of time in and out of working hours helping with the computation of the data. To all these the writer also wishes to express his thanks.

SUMMARY.

1. In the Bowmont Norway spruce plots each of four thinning treatments has been replicated four times. The development of these plots during the past 15 years is discussed.

2. Volume production per acre to date has been greater in the more heavily thinned D and L.C. grade plots than in the more lightly thinned B and C grade plots.

3. The average size of the 100 largest trees per acre is very much greater in the D and L.C. grades than in the B and C grades.

4. Height growth has been the same under all thinning treatments.

5. The heavier grades, and the L.C. grade in particular, have yielded not only more thinning produce but thinning produce of a larger size and hence of greater value than the lighter thinning grades.

6. Light Crown thinnings have not compared unfavourably with heavy low thinnings both in total increment and in the average size of final crop trees.

LITERATURE REFERENCES.

(1) Macdonald, J.: 'Sample Plot Methods in Great Britain.' *Empire Forestry Journal*, x, No. 2, 1931.

(2) Macdonald, J. A. B.: 'The Value of Early Thinnings in Norway Spruce.' *Scottish Forestry Journal*, xlvi, 2, 1932.

(3) —— 'The Annual Excursion of the Society.' *The Quarterly Journal of Forestry*, xxx, 1946, Part I, pp. 84–9.

Bowmont Forest. Norway spruce (*Picea abies* Karst.) 35 years old. After thinning, Sept. 1945. 1,515 stems left per acre. B grade

Bowmont Forest. Norway spruce (*Picea abies* Karst.) 35 years old. After thinning, Sept. 1945. 1,015 stems left per acre. C grade

PLATE III

Bowmont Forest. Norway spruce (*Picea abies* Karst.) 35 years old. After thinning, Sept. 1945. 387 stems left per acre. D grade

Bowmont Forest. Norway spruce (*Picea abies* Karst.) 35 years old. After thinning, Sept. 1945. 938 stems left per acre. L.C. grade

PLATE IV

THE STRENGTH OF HOME-GROWN TIMBER PIT-PROPS

By F. H. ARMSTRONG

(*Department of Scientific and Industrial Research, Forest Products Research Laboratory*)

INTRODUCTION.

THE strength of pit-props has been the subject of numerous investigations in the past. The earliest experiments appear to have been those of Professor Henry Louis (9), who in 1898 provided information on average strength values of home-grown and imported pit-props. Later Booth (3), stating that his results did not represent the strength of the timber from the scientific point of view, compared quartered with round pit-props. Both these investigators, while emphasizing the effect of proper seasoning on the strength of pit-props, did not appear to realize the full significance of the influence of moisture on strength, and no moisture-content determinations were made. A third investigator, Professor Hudson Beare (2), examined the suitability of Scottish-grown timber for pit-prop purposes. His results were somewhat inconclusive in that data on moisture content were lacking and comparative tests on Finnish timber were very limited.

Much more reliable data have been supplied by Dixon and Hogan (7), who in the course of a detailed investigation found that the home-grown pit-props compared favourably in some instances with the imported props. The importance of moisture was recognized and considered in discussing their results. Confirmation of these experiments has been provided by this laboratory, and Chaplin (6), in obtaining relative strengths of several home-grown species, found that for the same species and within reasonable limits of density the wood of home-grown timber is as strong as that of the imported timber.

Notwithstanding this more recent work, many colliery managements maintain that home-grown pit-props are inherently weaker, size for size, than props imported from the Baltic and elsewhere. This view is not supported by the available experimental data. Any difference in strength, if it exists, must be due to other factors such as growth characteristics and presence of defects.

This question of a comparative weakness of home-grown pit-props prompted the present investigation, which had as its aim the determination of the relative strengths of round home-grown pit-props of various species and the relating of the strength of each species to its physical characteristics and natural defects. A comparison with imported pit-props was also desired.

All earlier investigations have been in the main restricted to a comparison between home-grown and imported pit-props, to a determination of the strength of round and quartered pit-props, and to other specific considerations regarding mining timbers. So far as is known, no attempt has been made to investigate fully the influence on the strength of the many factors such as habitat, nominal specific

gravity (or density), rate of growth, initial curvature, size of knots, and length/diameter ratio, and the present research has been widened in scope to embrace such a study.

It is convenient to divide the paper into four main sections, namely:

I. The relative strength of home-grown pit-props.
II. The effect of influencing factors on strength and stiffness.
III. Comparison of home-grown and imported pit-props.
IV. General conclusions.

I. THE RELATIVE STRENGTH OF HOME-GROWN PIT-PROPS

FACTORS AFFECTING THE MECHANICAL PROPERTIES OF TIMBER.

It is instructive before proceeding with the account of the investigation to discuss very briefly the principal factors affecting the mechanical properties of timber. These are of two classes, namely, those which are extrinsic to the wood, such as moisture content, fungus attack, &c., and those which are inherent in the wood itself. In the latter class are nominal specific gravity,[1] rate of growth, knots, and defects.

Considering first the extrinsic factors, moisture content is well known to have great effect on mechanical properties. Wood in the green state contains considerable moisture, part of which is held absorbed in the cell walls, and part is held within the cell cavities. As wood dries, the cell walls do not give off moisture until all the free water in the adjacent cavities has been evaporated. The position in which the cell walls are fully saturated and the cell cavities empty is known as the fibre-saturation point. When the cell walls begin to lose moisture, that is, after the wood is dried to below the fibre-saturation point, increase in strength commences, and from this point the various strength properties are affected to a greater or lesser degree. Compressive strength, for example, increases considerably as drying continues, an increase which is much greater in small clear specimens of wood than in large timbers containing defects. In the latter the increase is to a large extent offset by the influence of defects, including those arising from drying.

To eliminate the influence of moisture content, testing is carried out at values of moisture content above the fibre-saturation point. Values for fibre-saturation point which have been determined from tests on clear specimens at the Forest Products Research Laboratory vary according to species; with softwood they range from about 23 to 32 per cent. moisture content.

Seriously decayed wood has very little mechanical strength. Tests made previously at this laboratory (1) show that the reduction in compressive and other strength properties is progressive with increase in fungal attack.

The strength properties of different species of wood vary considerably. Difference in strength may be accentuated by the relative tendency of different timbers, in particular softwoods, to contain defects. There is also a wide variation

[1] Throughout this paper nominal specific gravity refers to the ratio $\frac{\text{oven dry weight}}{\text{volume at test}}$ and hereinafter will be referred to as specific gravity.

in strength properties within a species, even when the influence of defects is eliminated. In both cases the variation may be ascribed mainly to the inherent factors, specific gravity, &c., already mentioned.

In general the higher the specific gravity the higher the mechanical properties. Tests on clear timber have shown that a general relationship exists between specific gravity and strength properties. Within a species specific gravity is an even better index of strength, and it has a fairly well-defined linear relationship with compressive strength.

In these same tests compressive strength has also been related to rate of growth as indicated by the average number of rings per inch. The relationship is less reliable than that of specific gravity and compressive strength, but within broad limits there is a gradual increase in compressive strength with decrease in rate of growth. Generally, rapidly grown softwood, i.e. a small number of rings per inch, is relatively weak, although occasionally when such wood is not associated with low weight the strength is not below average. With most softwoods, such as might be used for mining timbers, the rate of growth tends towards an optimum for strength, at about 12 rings per inch. This optimum rate of growth has been found to correspond generally to that which produces the higher specific gravity in the wood.

Knots interrupt the direction of grain and cause localized cross-section with steep slopes. The interruption of grain is much less serious in round material such as pit-props than in structural timbers. The angle which the irregular grain around the knots makes with the surface is less in the former than in the latter material, and furthermore the naturally round timber is often sufficiently enlarged at a knot or whorl of knots to compensate, to some extent, for the effect of irregular grain.

Little information is available regarding the effect of spiral grain on the strength of round material under compression loads, but it is known that with sawn material the compressive strength is not affected until slopes of grain of 1 in 10 or greater are reached.

EXPERIMENTAL MATERIAL.

The material for the investigation was obtained through the co-operation of the Forestry Commission, who arranged for a selection of pit-props from representative plantations throughout England, Scotland, and Wales. The chief softwood (coniferous) species grown in the United Kingdom were chosen for the tests. These were seven in number, namely, European larch (*Larix decidua* Mill.), Japanese larch (*Larix leptolepis* Gord.), Norway spruce (*Picea abies* Karst.), Sitka spruce (*Picea sitchensis* Carr.), Scots pine (*Pinus sylvestris* L.), Corsican pine (*Pinus nigra* var. *calabrica* Schneid.), and Douglas fir (*Pseudotsuga taxifolia* Brit.). Particulars of all the consignments of each species, together with details of locality, are compiled in Table VIII (at the end of this paper) from data supplied by officers of the Forestry Commission.

The material was so selected as to yield pit-props of four sizes with top diameters of 2½ inch, 3½ inch, 4½ inch, and 5½ inch, the range of sizes most

commonly used in the mines in this country. In each size-class twenty pit-props were cut during normal thinning[1] operations in the recommended plantations. In the case of species where pre-thinning[1] operations were carried out a full number of props of each size-class was also taken for test.

The pit-props, hereinafter referred to as props, of each size-class were supplied longer than required, to allow for trimming to a length for testing of twelve times the minimum top diameter. This is in accordance with average mining practice, although in different districts some collieries depart considerably from the average.

All the props were barked and trimmed before test and their preparation ensured cross-cutting the ends parallel with one another and perpendicular to the general axis.

No seasoning of the props was carried out, all the tests being made on green material. This is the condition of most timber when put into service in the mines.

METHOD OF TESTING.

The method of test was in accordance with normal laboratory procedure. The range of sizes of prop necessitated the use of two hydraulic testing machines, one of 200,000-lb. capacity for the two large size-classes of prop and one of 100,000-lb. capacity for the two small size-classes. The prop was centred in a vertical position in the machine between two spherical seated steel platens, one located on the weighing-beam and the other suspended from the loading-head. The positioning of both ends of the prop on the spherical seated platens ensured axial loading as far as possible, thus providing an even application of load to the prop. A small initial load was placed on the prop, after which the two platens were locked in position by means of set screws.

The load was applied at the rate of 200 lb. per sq. in. per minute, based on the small end of the prop, and the compression or shortening observed for either 1,000- or 2,000-lb. increments of load according to the size-class of prop tested. The reduction in length due to compression was read to 1/1,000th of an inch by means of a 6-inch dial compressometer and measured over the whole length of the prop, thus giving a direct comparison with actual conditions in the mine. This measurement was made on ten props from each size-class in each consignment.

The minimum and maximum diameters at the top and butt of each prop together with its length were measured prior to test. The knots in the whorl nearest the point of fracture were also measured and the proportion of the circumference occupied by these knots determined. All the props were weighed before test.

The amount of initial curvature, more commonly referred to as bow, of all the props was measured over the total length of the prop and expressed in inches per foot run. The method used for measuring bow is discussed later in the paper, in the section dealing with the influence of this factor on strength.

[1] 'Normal thinning' applies in this paper to relatively slowly grown and reasonably straight pit-props, with small knots. 'Pre-thinning' applies to wolf trees and rough wood.

Moisture content and rings per inch determinations were made on disks, cut as close as possible to the points of fracture, from each prop after test. The former determination was made mainly to confirm that each prop when tested had a moisture content above the value for the fibre-saturation point of the species, i.e. was in the green condition.

The specific gravity of a disk cut as described above and of each prop as a whole was also determined. In determining the latter it was assumed that the taper of each prop was approximately uniform. No special attention was paid to the small irregularities in the surface of the prop nor to the slight enlargements at knot whorls. The specific gravity of the prop is thus only approximate, but from the practical point of view such an approximation is reasonably accurate, particularly in the case of most props from normal thinnings.

To obtain data on the compressive strength of the timber of the props, small clear specimens were taken from parts of the larger size-classes of prop as far removed as possible from the fracture. The cross-section of these small specimens varied from 1 to 1½ inch square according to the overall diameter of the prop and the amount of clear timber available. These specimens were tested in compression in accordance with standard procedure (5).

EXPERIMENTAL RESULTS.

The results of the tests on the pre-thinning and normal thinning groups of props, which are recorded separately, are given in Table I. The average physical and mechanical properties of the individual consignments of each species are illustrated diagrammatically in Fig. 1.

In Table I two values of the maximum load (expressed as a unit stress in lb. per square inch) are recorded: one based on the mean top diameter and the other on the mean diameter of the prop, i.e. mean of top and butt diameters. The latter value allows comparisons to be made with the results obtained by other investigators who have used the mean diameter of the prop. In addition figures for the shortening of the props, recorded as a percentage of the total length, and figures for nominal specific gravity and for the density calculated at 50 per cent. moisture content are included. These two last named are the values as obtained for the whole prop.

GENERAL DISCUSSION.

Quality.

All the props were tested as received at the laboratory, and no rejections for abnormal bow or other growth irregularities were made. Some idea of the general quality of the material tested is afforded by the photographs showing representative props from the largest size-class of prop of one normal thinning consignment of each species. (Figs. 12–18, pls. V and VI.)

There was considerable difference in quality between pre-thinning and normal thinning groups of props. In most cases the former were irregular in shape, with large knot-whorls, while the material from normal thinning operations mainly gave reasonably clear and straight props in all consignments.

TABLE I. *Average Physical and Mechanical Properties of Home-grown Pit-props (All size-classes)*

Species	*Rings per inch*	*Nominal specific gravity*	*Density at 50% moisture content (lb./cu. ft.)*	*Maximum load based on*		*Modulus of elasticity (1,000 lb./sq. in.)*	*Shortening at maximum load (%)*
				Top diam. (lb./sq. in.)	*Mean diam. (lb./sq. in.)*		
(*a*) *Pre-thinning*							
European larch	8	0·448	41·8	2,310	2,040	860	0·87
Japanese larch	6	0·413	38·6	2,460	2,110	580	0·97
Scots pine	6	0·385	36·0	1,990	1,690	690	0·61
Corsican pine	8½	0·360	33·7	1,980	1,690	660	0·80
Douglas fir	5½	0·378	35·3	2,300	1,960	840	0·94
(*b*) *Normal thinning*							
European larch	8½	0·462	43·2	2,680	2,360	930	0·67
Japanese larch	6½	0·404	37·8	2,540	2,220	850	0·75
Norway spruce	10½	0·392	36·7	2,730	2,400	990	0·67
Sitka spruce	7	0·382	35·7	2,320	2,080	890	0·66
Scots pine	13½	0·418	39·1	2,480	2,210	840	0·71
Corsican pine	8½	0·397	37·1	2,370	2,140	880	0·61
Douglas fir	8	0·410	38·4	2,620	2,340	980	0·80

The prominence of bow in both European and Japanese larch, particularly the former, is a noteworthy feature. Even in the normal thinning groups of props of these species both single and double sweeps were found. Props with large amounts of bow were also found in some of the other timbers, in particular Scots pine and Douglas fir, but these were few in number.

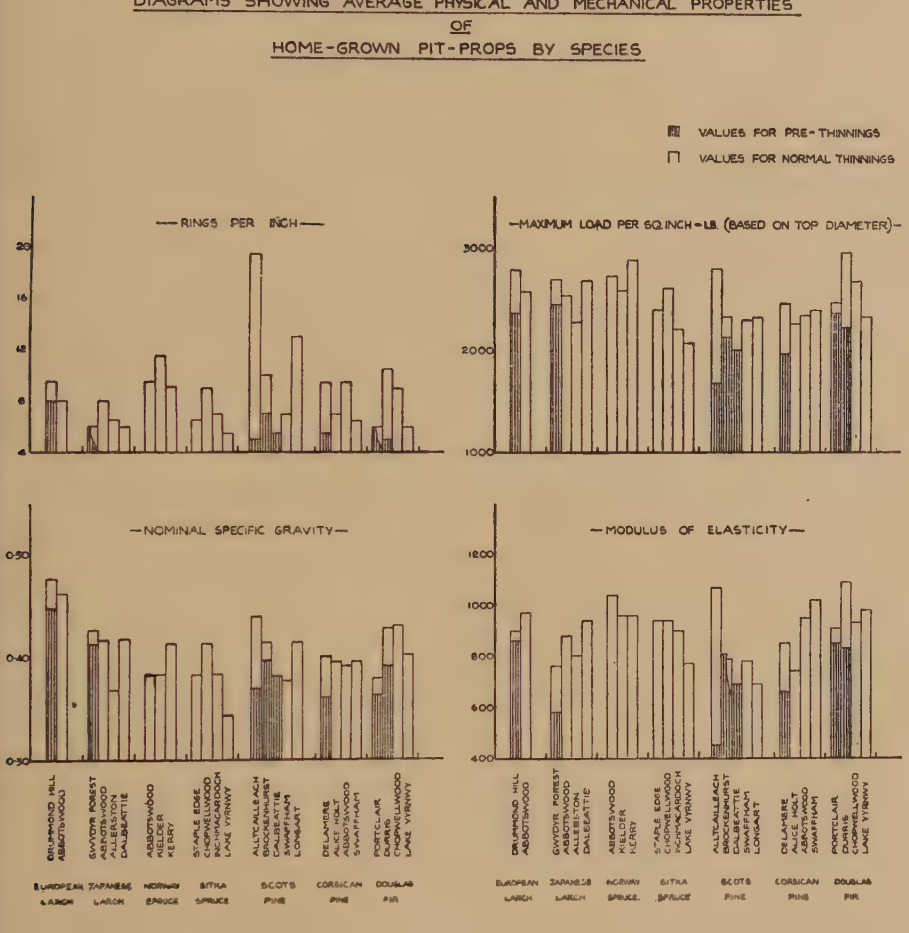


FIG. 1

Failure under Test.

The general type of failure was a buckling, which occurred with few exceptions in the direction of the bow and at its maximum. This was followed in the majority of cases by compression of the fibres across the concave side of the prop. Failure by direct crushing occurred in a few instances, particularly when knot-whorls were within a few inches from the top of the prop. This buckling was observed in all species, even those with pronounced knot-whorls, in which case it was usually followed by compression failure at or near a knot-whorl in the top

half of the props. Any inclination to bow tended to localize failure at the point of maximum curvature, and in such cases failure often occurred between adjacent knot-whorls.

General Survey of Results and Comparison of Species.

At this stage a general survey and comparison of the average physical and mechanical properties of the species as given in Table I is of interest. In the normal thinning group of props the variation in strength is not large, the range being of the order of 400 lb. per sq. in. The strength value taken for the purpose of analysis and discussion in the report, except where otherwise stated, is based on the average top diameter. The props can be considered as falling into two broad groups, those with average strengths of 2,500 lb. per sq. in. and over, and those with strengths below this figure. In the first group, in descending order of strength, are Norway spruce, European larch, Douglas fir, and Japanese larch. The difference between any adjacent pair of these species is very small, of the order of 2 to 3 per cent., and probably due to fluctuations of sampling, while between alternate pairs, i.e. between Norway spruce and Douglas fir and between European larch and Japanese larch, it is about 5 per cent. Norway spruce is superior in strength to Japanese larch by about 7 per cent. The second group comprises Scots pine, Corsican pine, and Sitka spruce, and again between any two adjacent species a very small difference is found. Scots pine, however, is stronger than Sitka spruce by about 6 per cent. It is of interest to note in this normal thinning group of props that the variation in modulus of elasticity, as between the seven species, is not great.

The average strength values of the poorer quality material in the pre-thinning group of props, which comprises five of the seven species, are, as expected, all considerably lower than those for the corresponding species in the normal thinning group of props. The order of variation in strength is approximately of the same order as that of the normal thinning group, but in modulus of elasticity the variation is greater.

The average percentage shortening of the various species of prop is not large, ranging in the normal thinning group of props from 0·61 to 0·80 per cent. and in the pre-thinning group from 0·61 to 0·96 per cent.

STATISTICAL CONSIDERATIONS.

Variability in properties is common to all materials, and wood is no exception. As has been mentioned, it shows a wide range in most of its strength properties. In tests of large-size timbers such as pit-props the spread or scatter of values is very great, more so than in the case of tests with clear wood. Earlier investigators encountering variability found difficulty in interpreting the results of their tests. Professor Louis, for example, failed to institute any satisfactory comparison between the strength of different species of props, and Dixon and Hogan emphasized the considerable variation which they found in their results.

The variability in the strength of wood is well illustrated by the diagrams in Fig. 2 (1 to 7) showing the frequency distribution of the strength of the

pit-props of each of the species tested in this investigation. For convenience the strengths have been grouped into classes at 200 lb. per sq. in. intervals. The distribution of the experimental results in each case is somewhat irregular, but in general it approximates to the normal distribution curve of statistics, the bell-shaped curve derived from the relevant data, shown by the full line in

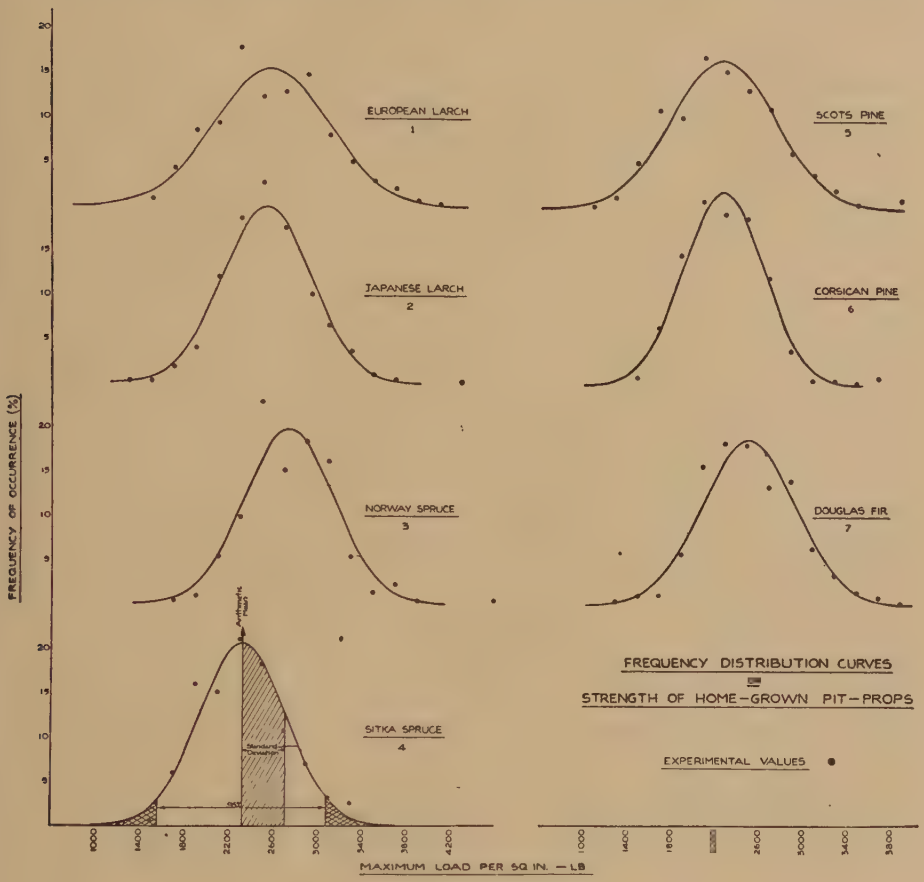


FIG. 2

each diagram. With increasing numbers of results the distribution of the experimental values in each case would approximate still more closely to the theoretical curve.

The theoretical curve corresponding to a number of results can be drawn if the two constants (or parameters), the arithmetic mean and the standard deviation, are known. The former is too well known to require definition; the latter is a convenient measure of the degree of variability of individual results about the mean. In effect it measures the 'scatter' of the distribution curve and is the point in the normal distribution at which it changes from convex to concave (Fig. 2 (4)).

The properties of this curve are well known and need not be considered in detail. In practice it is seldom necessary to draw it. Tables which are to be found in most books on statistics, together with the arithmetic mean and the standard deviation, will enable the probability of getting any particular limiting value to be estimated.

The use of statistical methods is also a valuable aid in the interpretation of results. Knowledge of the standard deviations enables the difference between the means of two sets of results to be assessed as significant, that is, as a real difference, or as due to the fluctuation of random sampling. The relations between two variables such as specific gravity and strength can also be conveniently determined.

Cases in which the number of observations or tests is fairly large, as in the present investigation, are convenient for statistical analysis, and throughout this work the methods described by Fisher (8) have been used.

II. THE EFFECT OF INFLUENCING FACTORS ON STRENGTH AND STIFFNESS

INFLUENCE OF HABITAT.

The influence of habitat on strength and other properties cannot be studied in great detail in the present investigation. A large number of factors are involved and the whole question of environment is exceedingly complicated.

The diagram in Fig. 1, however, shows that in the majority of cases differences in strength, and to a lesser extent in stiffness, exist between consignments of the same species taken from different localities. This is true for all species, the strengths of the consignments in some varying less widely than in others where one or two strengths are much superior to the remainder. In all species it will be noted that the differences in strength can in general be ascribed to differences in specific gravity or rate of growth or to a combination of these characteristics. As far as stiffness is concerned the results are more variable and the trend with physical characteristics is less definite.

Differences also exist, as would be expected, between the groups of props, pre-thinning and normal thinning, taken from the same locality. A comparison of the average strengths and stiffness of a pair of these groups in any one species shows that in almost all cases the reduction in the pre-thinning group of props is again due to one or other of the above-mentioned specific gravity or growth characteristics. In a few instances, as, for example, the Scots pine from Alltcailleach Forest, the Douglas fir from Durris Forest, and the Corsican pine from Delamere Forest, the reduction in the mechanical properties in each of the pre-thinning groups is very marked and is undoubtedly due to a combination of fast growth and low specific gravity.

Analysis has shown that these differences in strength and stiffness between the individual consignments, both in separate pre-thinning and normal thinning groups and in the pairs of consignments from both types of thinning, are with few exceptions significant and not due to fluctuations of sampling.

An analysis to determine whether there is a relation between elevation and strength has also been made. This was restricted in that the available data

covered only the approximate height above sea-level and not the more important relative elevation or height above adjacent lowland. Examination of the results, linking them with the particulars of elevation in Table VIII, indicates that a relation between this absolute elevation and strength does not exist. For example, Norway spruce props at 1,600 feet (Kerry Forest) have high strength, with those grown at 400–800 feet and at 700 feet (Forest of Dean and Kielder Forest), respectively, next in descending order of strength; while for Douglas fir normal-thinning props the order of strength is those grown at 300, 300–350, 100, and 1,300 feet. It is of interest to note that the Norway spruce grown at 1,600 feet is high in density, with a slow rate of growth, while the Douglas fir at 1,300 feet is of very fast growth and low in density. It would seem that local conditions coupled with silvicultural factors completely mask whatever effect absolute elevation may have on strength.

INFLUENCE OF SPECIFIC GRAVITY.

The general survey of the results illustrated diagrammatically in Fig. 1 shows that the influence of specific gravity on strength is apparent, an increase in specific gravity giving in general a corresponding increase in strength. In the case of stiffness the relationship with specific gravity is somewhat obscure and is not so evident from a study of the average results.

The specific gravity–strength relationship was examined in more detail. Diagrams in which the individual results for both pre-thinning and normal thinning groups of props have been plotted were prepared to show the range and trend of strength of each species. In addition the distribution of strength of the separate consignments is illustrated by distinctive symbols. The specific gravity used in this analysis was that obtained for the prop as a whole.

As mentioned, the results of the tests on each species were sufficiently numerous to afford material for a statistical analysis. The arithmetic mean and standard deviation of the strength of each species have been determined and the inter-relation of specific gravity and strength has been examined. The correlation coefficients of and thence the regressions of strength on specific gravity, i.e. the rate at which strength varies with specific gravity, were determined. It may be stated that the correlation coefficient always lies between $+1{\cdot}0$ and $-1{\cdot}0$. A coefficient of $+1{\cdot}0$ indicates a direct linear relation, one of $-1{\cdot}0$ an inverse linear relation, and one of $0{\cdot}0$ the absence of a relation between the two variables. Any intermediate value indicates imperfect correlation.

It was assumed that in the case of each individual species the relation connecting specific gravity with strength was approximately linear within the ranges of specific gravity under consideration. This assumption is permissible in a study of this nature on the grounds that other influencing factors such as rate of growth and knot–circumference ratio do themselves influence density. In some species, however, further factors, namely, bow and growth irregularities, have to be taken into account; and the extent to which they influence strength will be reflected in the correlation coefficients.

The specific gravity–strength relationship for each species, together with regression of strength on specific gravity, are illustrated in Fig. 3 (1–7). In these relationships the 95 per cent. limits have been added. These are shown dotted in the diagrams and indicate the limits between which 19 out of 20 of results lie. Thus only 1 prop in 40 would give a strength value that would fall outside the lower limit indicated, i.e. 97½ per cent. probability. The arithmetic means and standard deviations of the properties of each species, together with the correlation coefficients and the regressions of strength on specific gravity, are summarized in Table II. They can be studied in conjunction with the plotted results.

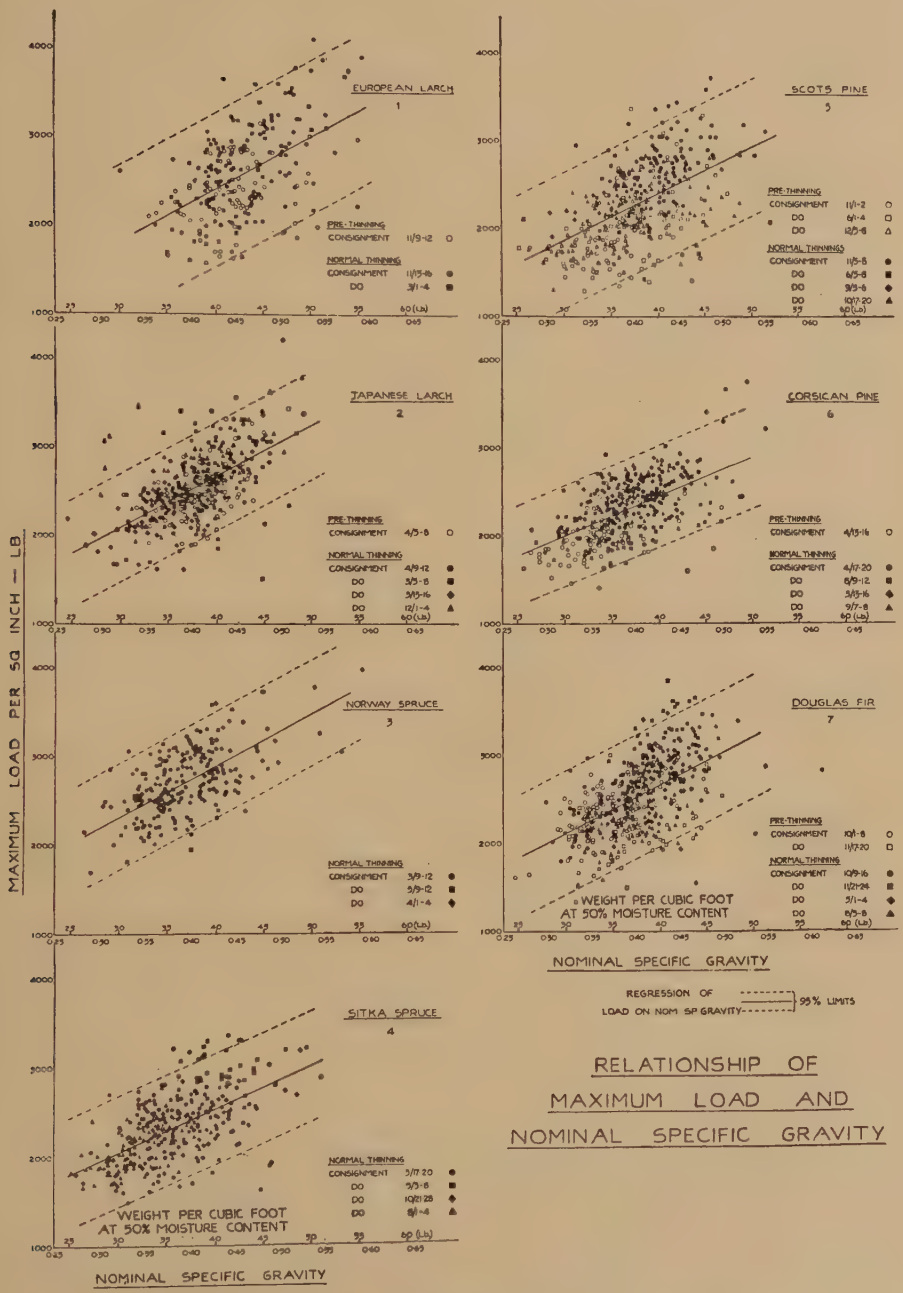
TABLE II. *Arithmetic Means and Standard Deviations of all Species with Correlation Coefficients and Regressions of Strength on Specific Gravity*

Species	*Strength*			
	Arithmetic mean (lb./sq. in.)	*Standard deviation*	*Correlation coefficient*	*Regression of strength on specific gravity*[1]
European larch .	2,570	511·0	+0·500	536
Japanese larch .	2,530	398·5	+0·618	544
Norway spruce .	2,740	403·1	+0·647	527
Sitka spruce . .	2,330	387·8	+0·578	439
Scots pine . .	2,270	472·1	+0·536	495
Corsican pine .	2,280	361·8	+0·572	422
Douglas fir . .	2,520	425·3	+0·547	500

[1] Change in strength for change in specific gravity of 0·10.

Considering the specific gravity–strength relationships it will be seen that the scatter of the plotted results is considerable in some of the species and this is reflected in the correlation coefficients. European larch with a wide distribution of individual results has the lowest correlation coefficient, while both Scots pine and Douglas fir, with a distribution somewhat less wide, have slightly improved coefficients. It will be remembered that European larch, as far as bow is concerned, was the worst species of those tested, while Scots pine and to a lesser degree Douglas fir had a large proportion of low quality pre-thinning props in their numbers. In the other species the scatter of results is comparatively narrow, being approximately of the same order in each case. All these timbers give correlation coefficients which are an improvement on that of European larch. It is noteworthy that the quality of the props in Norway spruce, Sitka spruce, and Corsican pine, all timbers in this last group, is in general much better than that of the other species; their number includes a greater proportion of props from normal thinning operations.

The actual values of the correlation coefficients for all the species indicate that the relationship of strength and specific gravity in each case is definite and may be regarded as fairly close. It will be appreciated that in a study of this nature a close



RELATIONSHIP OF MAXIMUM LOAD AND NOMINAL SPECIFIC GRAVITY

FIG. 3

relationship of the order of that generally obtained with small clear specimens of timber, i.e. 0·80 and over, is not possible. Apart from the fact that more than two interrelated variables are present in each case, other factors tend to affect strength to a considerable extent.

An analysis of the relationships of specific gravity–stiffness has given correlation coefficients that are small. The relationship existing between these two properties is not very close, and from the practical point of view cannot be considered as very definite. These relationships are not reproduced or considered further in the investigation.

INFLUENCE OF RATE OF GROWTH.

The influence of rate of growth on strength has been studied in detail. A wide variation in rate of growth was found to occur in the several consignments of props of some species and also in the individual props of these same species. With the latter the growth-rate across the cross-section was in many cases non-uniform, varying from very fast in the centre to extremely slow towards the outside. Occasionally in a few props a further change in growth-rate was noted on the extreme outer side of the cross-section.

This variation in rate of growth across the cross-sections of individual pit-props made it necessary to examine whether the usual method for determining the rate of growth and strength relationship, i.e. number of annual rings per inch and strength, was suitable in this case. Accordingly a preliminary examination of this relationship was made, as also were others, including that of range in width of annual ring, i.e. the difference between the maximum and the minimum width of annual rings measured over the cross-section of the prop and strength, and those of ratios of this range to either the number of annual rings per inch or the age. For this study disks from 240 props of Douglas fir, a species which has a wide range of growth-rate both in the separate consignments and in the individual props, were examined. Typical disks of Douglas fir showing the variation in rate of growth are shown in Fig. 4, pl. V.

The relationship of rate of growth and strength obtained from this examination is shown in Fig. 5 (1). Similar relationships for clear timber obtained from tests on small specimens of Douglas fir (green timber) carried out previously at this and other laboratories are included in the figure for comparison. It is clear that the trend of the rings per inch and strength relationship for the props follows reasonably closely that for the small specimens.

The relationship between range in width of annual rings and strength, Fig. 5 (2), indicates that there is little real difference in strength for wide variation in width of annual rings. Curves, not reproduced, were also drawn to examine the other relationships, as mentioned above, and these show also that for the ranges of ratios examined in each case the difference in strength is very small and probably insignificant. It is realized, however, that for any number of annual rings or at any age a small range in the width of rings, i.e. reasonably regular growth, across a section is preferable.

For the examination of the influence of the rate of growth on the strength, the

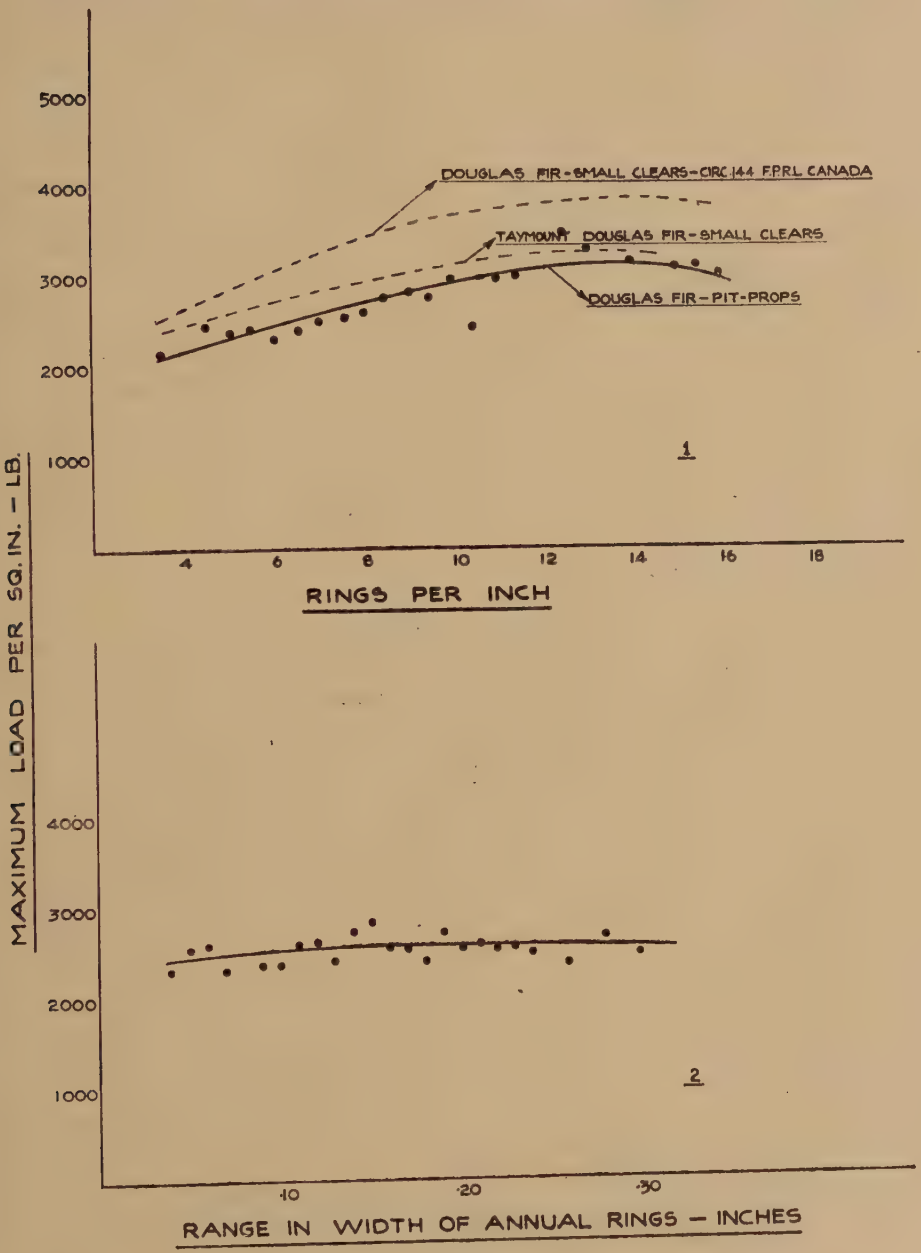


FIG. 5

normal procedure as discussed above has therefore been used for all the species. In each of these the range of annual rings per inch is sufficient to allow the trend of strength with rate of growth to be indicated, and in one instance to show optimum growth conditions within fairly narrow limits.

The curves reproduced in Fig. 6 (1–7) are based on the results of all the tests on the individual consignments of each species, including props both from the pre-thinning and normal thinning operations. Individual results are not plotted, but

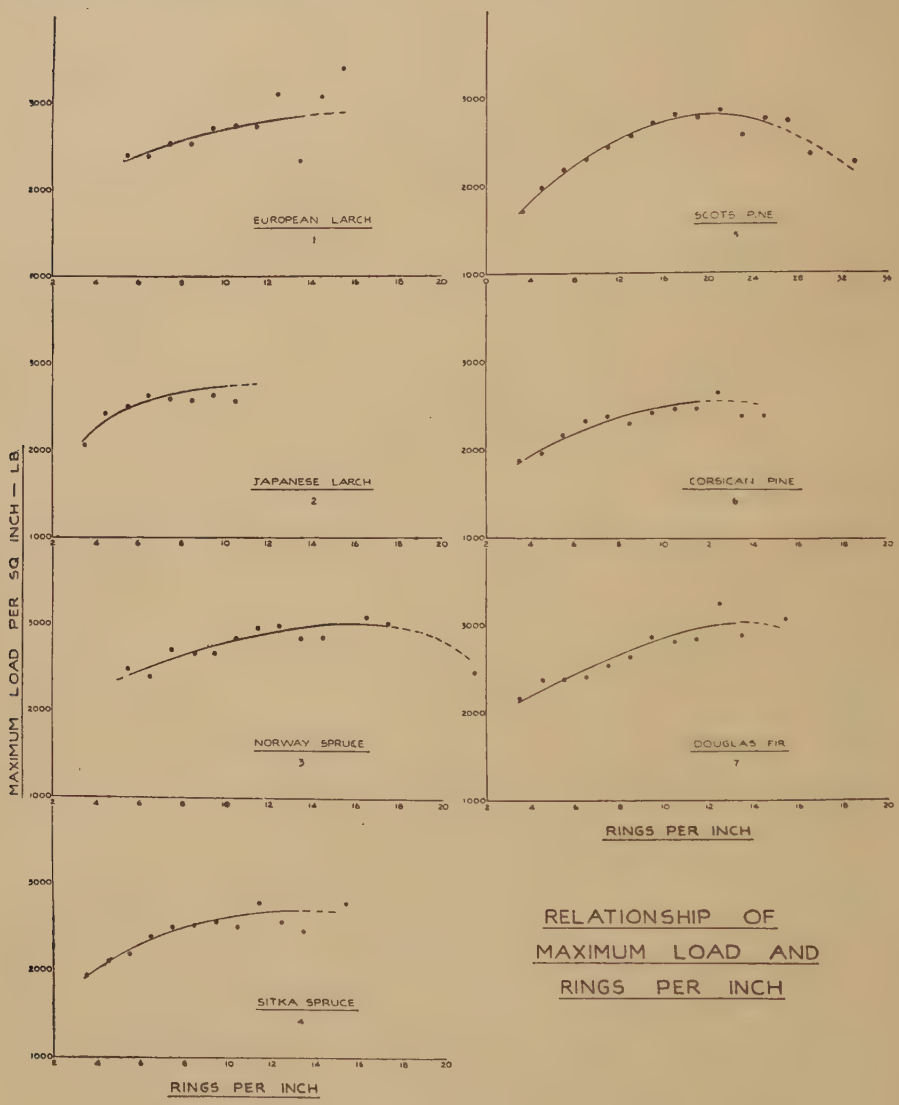


Fig. 6

each point represents an average of results at convenient growth intervals. The curves show the probable trend of strength with increase in number of rings per inch; where the points represent the average of only a small number of observations this trend is shown dotted.

A feature common to all the seven species is the decided increase in strength with decrease in rate of growth, an increase which appears to diminish as the growth-rate approaches from 12 to 14 rings per inch. All the species appear to be near optimum growth condition at this range, but in only one case, that of Scots pine, can the optimum growth be said to be well defined on the curve. Maximum strength in this species appears to be obtainable when the rate of growth is of the order of about 20 rings per inch, after which a fairly rapid falling off in strength occurs with very slow growth.

It was noted that props from pre-thinning operations in the species concerned gave individual results which were grouped in general about the lower end of the curves. The very fast grown material usual in this type of prop gives correspondingly low strength values. The grouping was particularly noticeable in the case of Scots pine, Corsican pine, and Douglas fir. The fast-grown material was also invariably low in specific gravity. In this connexion it is interesting to find that the distribution about the curves of the individual results of the various consignments of each species is reflected fairly closely in the distribution of the results of the same consignments in the corresponding specific gravity–strength relationships. In other words, as far as strength is concerned the consignments of each species tending to have a rate of growth corresponding to maximum strength are all comparatively high in specific gravity.

INFLUENCE OF BOW.

Bow was present in varying amounts in the majority of the props of all seven species. It is, as has already been stated, very common in the larches, both European and Japanese, and in some instances the amount of bow in these species was considerable.

Bow is measured over the total length of the prop and is expressed in inches per foot run. A measure of the bow in each prop can be obtained conveniently by means of a straight-edge laid along the length of the prop and a measurement taken at the point of maximum offset. In this investigation, however, it was desirable to measure the bow of the centre axis and this was made possible by means of an apparatus designed for the purpose.

In this apparatus the prop is centred in two six-pronged chucks, so that it revolves on its axis. One chuck is fixed on the base plate of the apparatus and the other is carried on a movable frame which slides vertically between two upright columns and can therefore be adjusted to suit any length of prop. The measuring device likewise slides vertically between the columns and can be positioned to measure the maximum bow. A plunger, equipped at one end with a small wheel as a follower to the prop as it revolves, is free to slide horizontally and actuate two stops, one of which carries a suitable scale and the other a pointer. As the prop revolves the actual bow of the axis can be read off directly.

The relationship between bow and strength is shown in Fig. 7. The results for only four of the species have been plotted, as only in these timbers was the range of bow of the species sufficient to enable the probable trend of strength with bow to be determined. Each point on the separate curves represents the average for a

group of props within the range of bow of 0·05 inch per foot run. All species show trends which are fairly well defined, particularly so in the case of European larch.

The reduction in strength with increase in bow is fairly considerable in all four

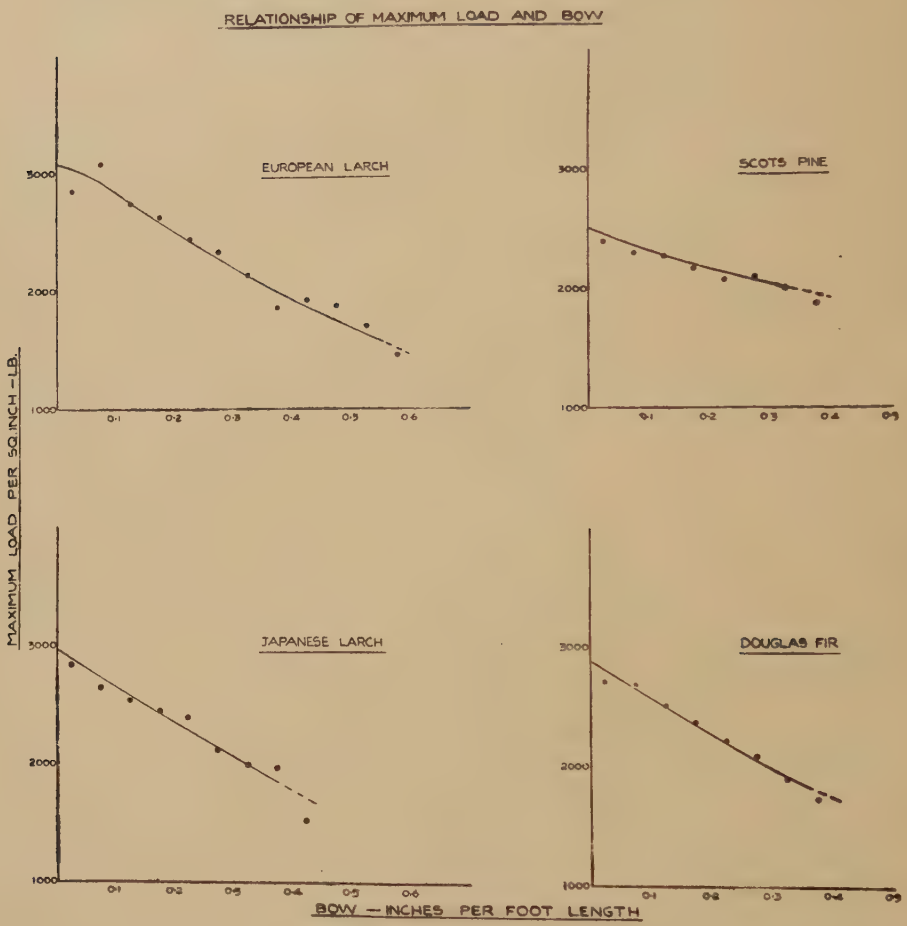


FIG. 7

species. The curves for both larches, European and Japanese, and Douglas fir show that with bow of 0·3 inch per foot run the reduction is of the order of 30 per cent., while that for Scots pine for the same amount of bow indicates a reduction of 20 per cent.

The relationship between bow and stiffness for the same four species is shown in Fig. 8. Individual results have not been plotted, but each point on the separate curves again represents the average for a group of props within the range of bow of 0·05 inch per foot run.

The curves show that the reduction in stiffness for a bow of 0·3 inch per foot run is as in the case of strength again fairly considerable. For European larch it is of the order of 40 per cent. while for each of the other three species it is about 20 per cent.

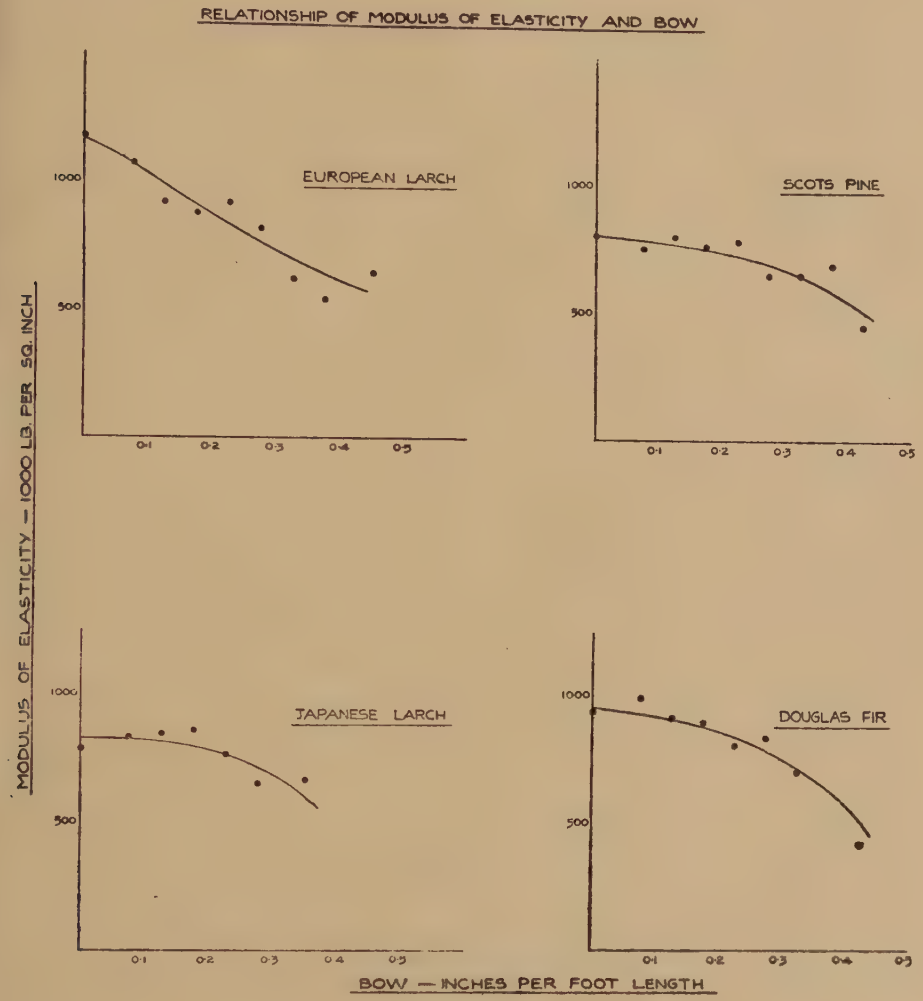


FIG. 8

Bow may thus be considered as having a marked influence on both the strength and stiffness of the props.

INFLUENCE OF KNOT-WHORLS.

As mentioned earlier in the paper, the initial buckling under test was usually followed by compression at or near a knot-whorl in the top half of the props. Over 64 per cent. of the Scots pine props tested failed in this manner, with a

further 17 per cent. failing by direct crushing. In this latter case the knot-whorls were within a few inches from the top of the props.

The knot-whorls varied considerably in size and are expressed as a ratio of the sum of the total knot widths to the circumference. Each knot was measured in the direction of the circumference of the prop, and the circumference itself was calculated from the mean top diameter. The ratio for each prop was that for the whorl at or near which failure occurred. No consideration was given to any other knot-whorl or to whorls in the lower half of the prop.

The two species in which knot-whorls were most prominent and in which a considerable range of knot/circumference ratios was present were Scots pine and Douglas fir. Of the other timbers both European and Japanese larch were comparatively free from knot-whorls, while in the spruces, Norway and Sitka, and also in Corsican pine they were in general relatively small, with insufficient range in knot/circumference ratios.

The relationship of strength and knot/circumference ratio was studied for two species, Scots pine and Douglas fir. The trend in both cases, which is fairly well defined, is shown in Fig. 9. Each point on the individual curves represents the average of a group of props within the range of knot/circumference ratio of 0·05.

The curves show that the strength of both species decreases until a knot/circumference ratio of about 0·30 is reached—a decrease in strength which is much more marked with Scots pine than with Douglas fir—after which there is little change in strength up to a ratio of 0·70. At that point the curves appear to fall away, suggesting a further reduction in strength at the very large knot/circumference ratios, but individual results at these ratios are too few for the trend to be definite.

It was found from an examination of the individual results that at small ratios the trend of strength appears to be due to the distribution of the individual results from props of comparatively high specific gravity. For example, Scots pine props of consignments 11/5–8 and also Douglas fir props of consignments 10/9–16 and 5/1–4, all of comparatively high specific gravity, appear to have a decided influence on the trend of the respective relationships. This is confirmed when specific gravity is plotted against knot/circumference ratio for both these species. The curves thus obtained, Fig. 10, are similar in type. In particular the similarity of the two Scots pine relationships is very marked. Thus it would appear that any loss in strength in the props with knot/circumference ratios up to 0·30, i.e. where knots cover up to one-third of the circumference, is due entirely to change in specific gravity independently of the knots. Beyond this value, and up to a ratio of 0·70, the strength does not appear to change with increasing knot/circumference ratio. It should be emphasized in this connexion that these props with large ratios are mainly from pre-thinning operations.

LENGTH/DIAMETER RATIO.

It is a well-known fact that the strength of a compression member depends on the ratio of length to minimum diameter (L/D), or on the slenderness ratio which

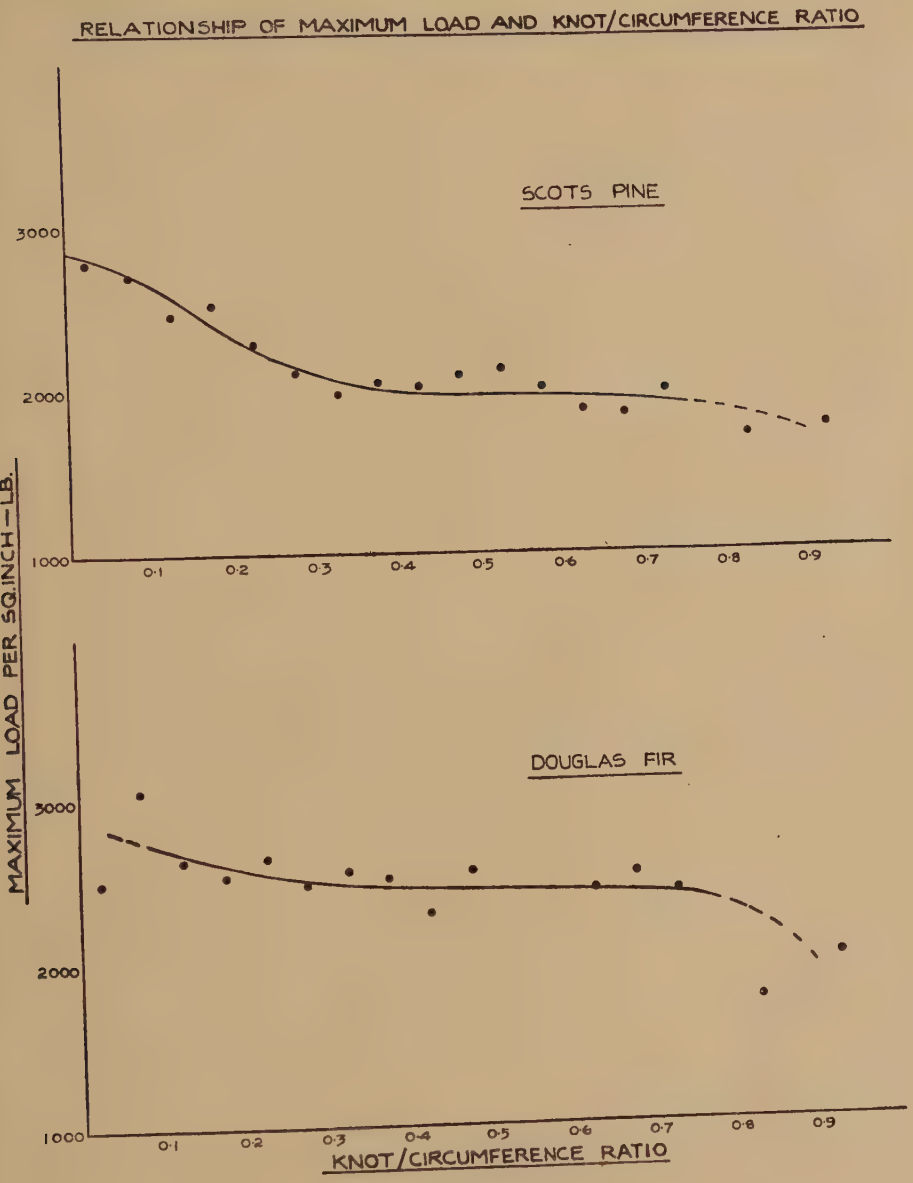


FIG. 9

is expressed as the ratio of the length to the radius of gyration of the cross-section (L/K). For very short compression members (L/D not greater than about 11), where the critical property is the compressive strength of the timber, it is assumed that strength is not influenced to any marked extent by variation in the L/D ratio, but beyond this limit increasing ratios result in significant reductions in strength.

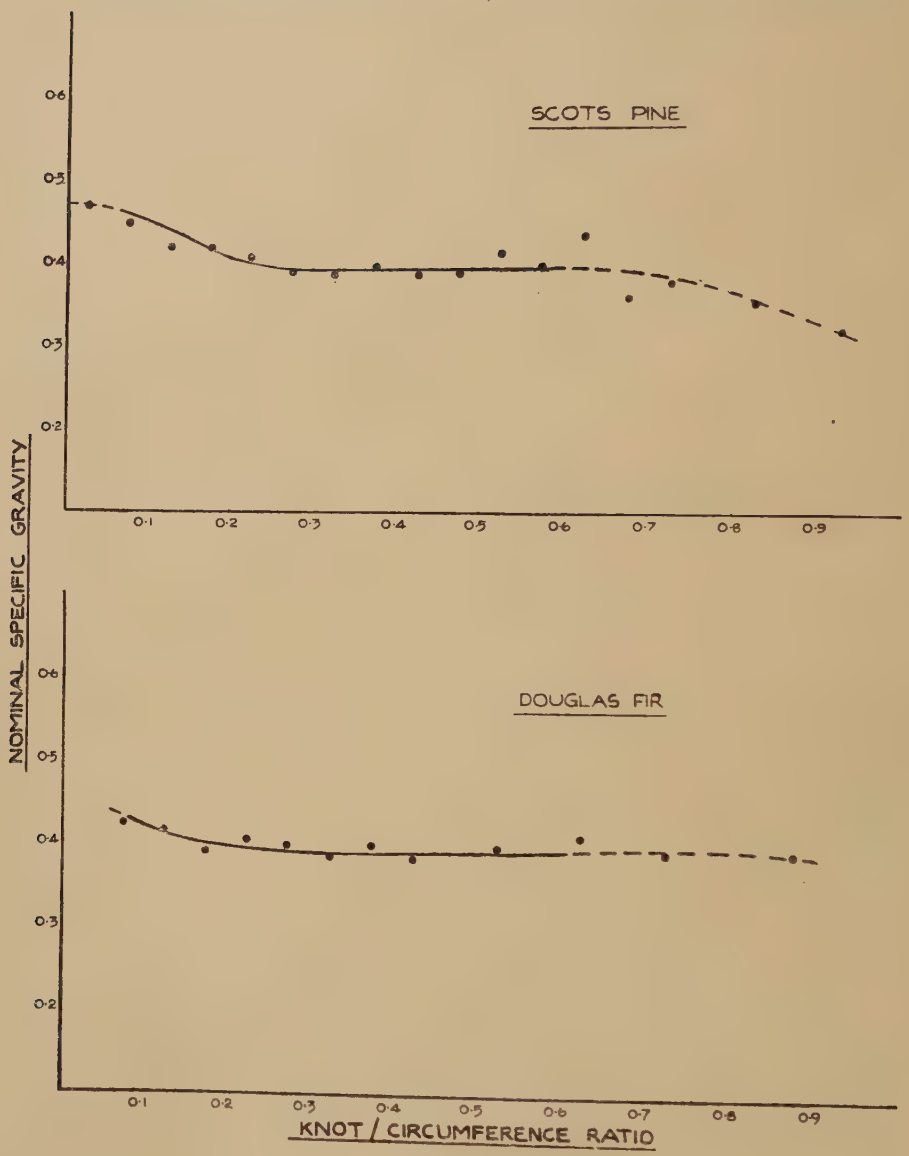


Fig. 10

In mining, the length of a prop depends on the thickness of the coal seam, and the top diameter of a prop is usually reckoned as being one-twelfth of its length. This ratio of L/D is normal mining practice but, as has been stated, in some districts, collieries may, and do, depart considerably from this standard. Ratios varying from 10 to 20 and even up to 27 are often found.

In order to examine the effect on strength of variation of L/D ratio some supplementary tests were made on a consignment of props, 100 in all, of Japanese larch. These props were divided into groups of various top diameters and were cut to length to give a range of ratios from 4 to 22.

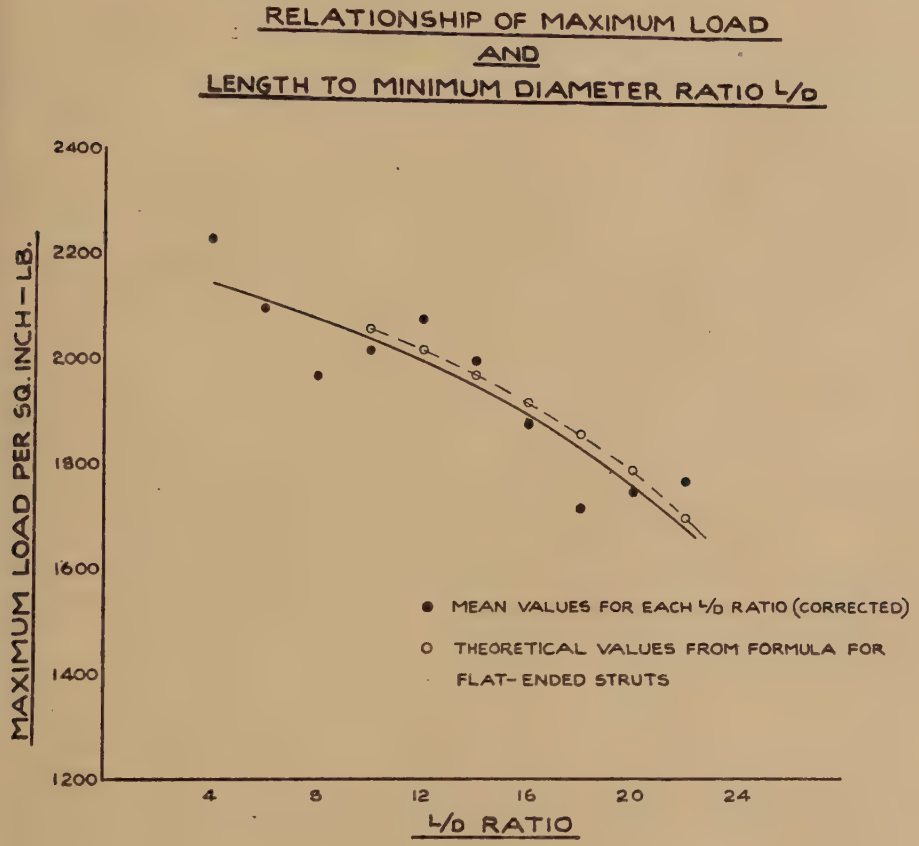


FIG. 11

The results of these tests have been plotted in Fig. 11. The experimental results for each group of props and the various L/D values have been corrected to the average specific gravity and the average rate of growth, about 0·34 and 6 rings per inch, respectively, for this particular consignment of Japanese larch. A theoretical curve for struts of intermediate length, i.e. with L/D ratios from 10 to 40, based on the Perry formula modified by Robertson (10), has been superimposed on the diagram and will be seen to fit the experimental values reasonably well. This formula includes a factor to allow for any eccentricity of loading and initial curvature and is adapted to conditions applicable to flat-ended struts or conditions which may be assumed reasonable for pit-props.

There is a gradual diminution of strength with increase in L/D ratio. Up to a value of $L/D = 12$ the reduction in strength is of the order of 20 lb. per unit

increase in L/D ratio. This confirms the conclusions arrived at by Bowen (4) and by Dixon and Hogan (7). At slight differences in L/D ratio this reduction is from a practical point of view insignificant. At values over 12, however, the reduction becomes gradually greater and is important, especially if comparisons are to be made where ratios differ widely.

STRENGTH OF THE TIMBER OF THE PIT-PROPS.

As mentioned, tests were made on small specimens of clear timber in order to obtain data on the compressive strength of the timber of the props. The specimens, whose ratio of length to least dimension was 4, were taken from props of each of the species and varied from 1 inch to 1½ inches square in cross-section. They were all free from defects.

The results of these tests are given in Table III, together with the average strength values (based on mean diameter in this case, for comparison with the work of other experimenters) of the normal thinning groups of props.

TABLE III. *Average Compressive Strength of Small Clear Specimens of the Timber of the Pit-props compared with Values from Tests on Whole Props*

	Clear timber		*Props (normal thinning groups)*	*Stress at maximum load (per cent. of maximum compressive strength)*
	Nominal specific gravity	*Maximum compressive strength (lb./sq. in.)*	*Maximum load*[1] *(lb./sq. in.)*	
European larch	0·440	2,780	2,360	84·8
Japanese larch	0·371	2,560	2,220	86·7
Norway spruce	0·368	2,870	2,400	83·6
Sitka spruce	0·328	2,310	2,080	90·1
Scots pine	0·390	2,650	2,200	83·0
Corsican pine	0·359	2,430	2,140	88·2
Douglas fir	0·369	2,860	2,340	81·8

[1] Based on mean diameter.

The average strength of the whole props is thus of the order of 80 to 90 per cent. of that of their clear timber. It varies according to species, ranging from 82 per cent. for Douglas fir to 90 per cent. for Sitka spruce. On a weight-for-weight basis the range varies from 67 per cent. for Douglas fir to 79 per cent. for European larch. The former values compare favourably with the 82 per cent. obtained by Dixon and Hogan (7). This comparison is approximate, as it has been emphasized by these investigators that in determining the strength of timber of Norway props no special attention was paid to knots in the small portions selected for this purpose. It is probable that the strength so determined was slightly lower than would normally have been obtained from tests on specimens entirely free from defects.

III. COMPARISON OF HOME-GROWN AND IMPORTED PIT-PROPS

It had been hoped to include imported Baltic redwood (Scots pine) (*Pinus sylvestris* L.) for test in the present investigation, so as to afford a direct comparison with the home-grown species, but conditions existing at the time prevented suitable supplies from being obtained. Previous work, notably by Dixon and Hogan (7), and Chaplin (6), included tests on both Baltic redwood (Scots pine) and maritime pine (*Pinus pinaster* Ait.). The results of these, although based on a limited quantity of material, provide an approximate basis for comparison. The ratio of length to least diameter in either work was not 12 as in the present series of tests. In the tests carried out by Dixon and Hogan it varied between about 11 and 14, while in those by Chaplin it was as much as 18.

Average strength values for the imported props of Baltic redwood and maritime pine, tested in the green condition, are reproduced in Table IV. The strength of

TABLE IV. *Comparative Strength of Imported and Home-grown Props tested in the Green Condition*

Species	*Source*	*Strength based on mean diameter (lb./sq. in.)*
Scots pine (from Norway)	Safety in Mines Research Board (Dixon and Hogan)	2,390[1]
Maritime pine (*Pinus pinaster* Ait.)		2,120[2]
Scots pine (imported)	Bulletin No. 9 (Chaplin)	2,320[3]
Maritime pine		2,140[3]
Home-grown species		
(*a*) *Pre-thinning*		
European larch	..	2,040
Japanese larch	..	2,110
Scots pine	..	1,690
Corsican pine	..	1,690
Douglas fir	..	1,960
(*b*) *Normal thinning*		
European larch	..	2,360
Japanese larch	..	2,220
Norway spruce	..	2,400
Sitka spruce	..	2,080
Scots pine	..	2,210
Corsican pine	..	2,140
Douglas fir	..	2,340

[1] Average for 1 group of 10 props. [2] Average for 7 groups of 10 props.
[3] Corrected for L/D ratio and based on mean diameter.

the props given in Bulletin No. 9 (Chaplin) is based on top diameter and not, as in the case of the tests by Dixon and Hogan, on the mean diameter. To permit comparison a reduction in the strength of the former props was made to adjust

for differences in diameter, but this was partially offset by an increase to compensate for L/D ratio. The corrected values are approximately 2,320 lb. per sq. in. for the imported Scots pine and 2,140 lb. per sq. in. for the maritime pine, both of which are reasonably close to the corresponding values obtained by Dixon and Hogan.

The values for the home-grown species are also tabulated. They include the average strength (based on mean diameter in this instance) for each species, separately for pre-thinning and normal thinning props, and are reproduced from Table I for convenience.

Considering first the average strengths of the pre-thinning props (*a*), it will be seen that all the home-grown species tested in this group are inferior to the Baltic redwood (2,390 lb. per sq. in.). The inferiority in strength varies from about 12 per cent. for Japanese larch to over 29 per cent., a considerable drop, for Scots pine and Corsican pine. European larch and Douglas fir are inferior in strength to the imported Scots pine by about 15 and 18 per cent. respectively. With the exception of Japanese larch, all the species in this group are appreciably weaker than maritime pine (2,120 lb. per sq. in.).

This comparatively low strength of the props from pre-thinning operations is to be expected. It will be recalled that these props are, in general, very poor in quality. Comparisons between the pre-thinning and normal thinning groups of props of individual consignments of the various species, and the subsequent discussion of the factors influencing strength (earlier in the paper), have shown that the lower average strength of the pre-thinnings can be ascribed to low specific gravity or fast rate of growth or bow, or to combinations of these factors.

Fortunately props from pre-thinning operations are not likely to bulk largely in supplies to the miner. It is reported that in practice this class of prop does not exceed about 1 per cent. of the total, in which case the average strength value of all thinnings will not be affected to any significant extent. The (*b*) group figures may therefore be accepted as representative of the respective home-grown species and used as the basis of comparison with imported props.

A comparison of the average strengths of the normal thinning props (*b*) with those of the imported props is not unfavourable to the home-grown timbers. Two of the latter, Norway spruce and European larch, are approximately equal in average strength to the Baltic redwood, and Douglas fir shows only a 2 per cent. inferiority. Japanese larch and Scots pine are about 7 per cent., Corsican pine 10 per cent., and Sitka spruce 13 per cent. less strong than Baltic redwood. Even the Sitka spruce, it will be noted, is only about 2 per cent. inferior to maritime pine.

In the past there has been, for the most part, a preference for Baltic redwood props in the mines of England and Scotland. This has been due principally to the straightness of the props, which has facilitated stacking for transport and storage, and to their smoothness, a factor conducive to ease in handling in the mines. It is probably true to say that this straightness and freedom from snags has inspired a certain amount of confidence in the strength of the props.

The average strength of Baltic redwood props is given in Table IV. Rounded off to 2,400 lb. per sq. in. (based on mean diameter) it is accepted by the Safety in

Mines Research Board as an average for good-quality props. Using the ratio of strength based on top diameter to strength based on mean diameter for props of L/D ratio of 12, the figure, related to average top diameter, may be taken as 2,650 lb. per sq. in.

Vast quantities of home-grown props of all the species tested have been used during the war and apparently have proved serviceable, in both general quality and strength. So far as is known there is no evidence to the contrary. The quality of the props from the normal thinning operations has been discussed earlier in the paper. In general most of the species in this group, with perhaps the exception of European larch, in which bow was found to be considerable, gave reasonably clear and straight props in all consignments. As these can be assumed to be representative, it is reasonable to conclude that mining supplies have not differed materially in quality. Again, so far as load-bearing capacity is concerned, there has been no evidence to show that average strengths of the order of those obtained for each of the species in the normal thinning group have not been adequate. This suggests that the slightly lower strength of some of the species is relatively unimportant.

Thus it appears that war-time requirements of props have been met by the use of home-grown softwoods, three of which can be accepted as approximately equal in strength to the imported Scots pine, with others less strong but in no instance weaker than by about 13 per cent. It may be mentioned that the lower strength found for Japanese larch and Scots pine, compared with Baltic redwood, is not significant statistically and may well be due to fluctuations of sampling. Such small differences in strength cannot be said to constitute an inherent weakness. Further, in fairness to the home-grown softwoods it must be pointed out that the average strength of unseasoned Baltic redwood props, i.e. 2,390 lb. per sq. in., based on mean diameter, may not be truly representative of the imported material, since the tests on which it has been established were only ten in number.

Consideration of the standard deviation of the average of these imported props supports this view. Just as a set of individual values may be arranged in the form of a frequency distribution which has a certain 'spread' (a multiple of the standard deviation) about its mean value, so the means of a series of batches of specimens are distributed about a grand mean, and the 'spread' of their distribution is similarly a multiple of the standard deviation of the mean. With small numbers of specimens this is usually large. For example, analysis of the results given by Dixon and Hogan (7) shows that the standard deviation of the mean of the Baltic props is of the order of ± 205 lb., a much higher variation than that obtained for the average strength of any of the home-grown species tested in this present investigation, and therefore less reliable.

On the other hand, insistence on the accepted strength value for good-quality imported Scots pine might cause the rejection of some home-grown softwoods, and the view may be held in some quarters that there is justification for improving their separate average strengths so as to approach more closely to, or even exceed, the strength value of 2,400 lb. per sq. in. or the equivalent top-diameter value of 2,650 lb. per sq. in. In that case a measure of selection will be necessary. In

addition to the rejection of all the props from pre-thinning operations a further grading will be required to eliminate props with large amounts of bow and those low in specific gravity.

It is important, therefore, to examine briefly what improvements in average strengths might be obtained from selection of this type. It has been shown that for a constant L/D ratio the factors most concerned with strength of props are bow, specific gravity, and rate of growth. The first of these affects strength to a marked degree. It is not necessarily an intrinsic property of the species and can conveniently be examined separately.

For this purpose an arbitrary value of 0·25 inch per foot length was selected for the limit of permissible bow—it was not desirable to fix too exacting a limit—and the improvement in average strength after elimination of props exceeding this limit is shown in Table V. The values for four of the species only are tabulated. In the remaining species the number of props with any considerable amount of bow was very small.

TABLE V. *Average Strength of Home-grown Pit-props (Normal Thinning Group) after Rejection for Bow*

Species	*Strength—based on top diameter*		*Increase in strength* (%)	*Number of rejections* (%)
	Ungraded (*lb./sq. in.*)	*Graded—bow not exceeding 0·25 in. per foot* (*lb./sq. in.*)		
Normal thinning				
European larch .	2,680	2,820	5·0	19·5
Japanese larch .	2,540	2,580	1·6	6·0
Scots pine . .	2,480	2,500	0·8	4·7
Douglas fir . .	2,620	2,650	1·1	4·8

It will be noted that the species benefiting most from limitation of bow is European larch. About 20 per cent. of the total number of props have been rejected. The average strength has increased by about 5 per cent., making it slightly superior to that of the imported Scots pine. The positions of the remaining species in this respect show only slight improvement. The percentage rejections in each case are small and the increases in strength are only of the order of 1 to 2 per cent. Considerable numbers of props of these three species are fast grown and consequently low in specific gravity.

To eliminate the low-density material a minimum number of rings per inch was selected for each species from the curves showing the relationship between rings per inch and strength (Fig. 6). This corresponded on the curves to a strength varying from 80 to 90 per cent. of the accepted strength value of 2,650 lb. per sq. in. (top diameter) for Baltic redwood, and proved to be for all species with the exception of Scots pine at 6 rings per inch. The minimum number of rings per inch chosen for Scots pine was 8.

Grading on this additional basis of rings per inch resulted in the elimination of considerable numbers of low-density props and gave a general increase in average strength. The comparative values are given in Table VI which shows the average strengths of (i) the ungraded props, (ii) the props after rejections for bow, and (iii) the props after rejections for bow and too rapid growth. Percentage increases in strength and percentage rejections of props are also tabulated.

TABLE VI. *Average Strength of Home-grown Pit-props after Rejection for Bow (0·25 inch per foot) and Minimum Rings per Inch*

Species	*Strength—based on top diameter*			*Total increase in strength* (%)	*Total number of rejections* (%)
	Ungraded (lb./sq. in.) (i)	*Graded—bow not exceeding 0·25 in. per foot (lb./sq. in.)* (ii)	*Graded—bow and rings per inch (lb./sq. in.)* (iii)		
Normal thinning					
European larch.	2,680	2,820	2,840	6·0	23·9
Japanese larch .	2,540	2,580	2,660	4·7	39·7
Norway spruce	2,730	..	2,760	1·1	4·0
Sitka spruce .	2,320	..	2,480	6·9	42·0
Scots pine .	2,480	2,500	2,560	3·2	22·1
Corsican pine .	2,370	..	2,400	1·3	14·9
Douglas fir .	2,620	2,650	2,710	3·4	29·4

Taking 2,650 lb. per sq. in. as the accepted strength value (based on top diameter) for Baltic redwood, three of the home-grown species, European larch, Norway spruce, and Douglas fir, are slightly superior to the imported redwood by about 7, 4, and 2 per cent. respectively, while Japanese larch has approximately equal strength. The remaining three species, Scots pine, Sitka spruce, and Corsican pine, are still slightly less strong than the imported material but they now approach more closely to it. The comparison with the Baltic redwood, as far as Scots pine and Sitka spruce are concerned, is more favourable than before. The inferiority in strength of these two species, 3 per cent. and 6 per cent. respectively, is not significant statistically. Corsican pine shows little improvement in average strength and is least affected by the grading. It remains nearly 10 per cent. inferior in strength to the imported Baltic redwood.

An interesting effect of grading, not apparent from a study of the average strength values, is the improvement in minimum values in some of the weaker species. These minimum strength values have been calculated from the statistical data for all the ungraded props and for all the props after rejections for bow and rings per inch and are tabulated in Table VII. It may be stated that an estimated minimum is the strength value below which only $2\frac{1}{2}$ per cent. of the results, i.e. 1 in 40, a reasonable probability, might be expected to lie. It is the lower limit of the 95 per cent. range shown on the distribution curve, Fig. 2 (4).

A comparison of these estimated minima shows that there is a general levelling up of values. Particular attention is invited to the figures for Sitka spruce, Scots pine, and Corsican pine.

TABLE VII. *Estimated Minimum Strength Values (97½ per cent. Probability) for both Ungraded and Graded Props*

Species	*Estimated minimum strength*[1] *(lb./sq. in.)*	
	Ungraded	*Graded for bow and rings per inch*
European larch .	1,570	1,830
Japanese larch. .	1,750	1,890
Norway spruce .	1,950	1,980
Sitka spruce . .	1,570	1,750
Scots pine . .	1,340	1,790
Corsican pine . .	1,570	1,710
Douglas fir . .	1,690	1,860

[1] Based on top diameter.

Whether any of the improvements in strength discussed above justify a scheme of selection on the lines examined, with in some cases relatively large percentage rejections of props, notably Japanese larch, Sitka spruce, and Douglas fir, is a question that cannot be decided without reference to many factors beyond the scope of this paper. The economic implications of such a scheme would require consideration by the organizations concerned before deciding the question. It can be recommended, however, that pre-thinning props, which are only an exceedingly small proportion of the total supplies, should not be used. In particular, this applies to wolf trees (fast-growing individuals taller than the average) and those props which have been taken from heavily branched trees.

IV. GENERAL CONCLUSIONS

The results of the investigation group the seven home-grown species in an order of strength as props and show that the strength of a prop is dependent on growth characteristics and other factors. The more important points resulting from the analysis of the results can be summarized as follows:

1. A fairly close and definite relationship exists between prop strength and specific gravity, the strength increasing approximately in proportion to the increase in specific gravity.
2. The strength of the prop depends on the rate of growth, optimum growth conditions varying according to species. Within broad limits the rate of growth is an index of specific gravity.
3. Bow affects strength and stiffness to a marked degree.
4. Knot-whorls are not of great importance, apart from considerations of appearance, ease in handling, &c. Any loss in strength with increase in the

knot/circumference ratio, up to about 0·30, is due entirely to change of density independently of the knots.

5. The strength of whole props of each species, assuming a ratio of $L/D = 12$, is upwards of 80 to 90 per cent. of the maximum compressive strength of the clear timber of the same props.
6. The strength of a prop decreases as the slenderness ratio increases.

It is indicated conclusively that when of good quality, as, for instance, when taken from normal thinning operations, the home-grown softwoods compare favourably with Baltic redwood. Some species and also some individual consignments of most of the species are equal in strength to the imported Scots pine, while others are only slightly less strong. The comparatively poor strength of the props from pre-thinning operations has been emphasized and it is recommended that these should not be used in the mines.

It has been shown, further, that selection aimed at the elimination of props with excessive bow and those which are fast grown and low in specific gravity improves the quality and strength of home-grown soft-woods and makes them compare even better with imported props than when ungraded.

The decrease in strength with increase in slenderness ratio has been examined. Any marked increase above that of the average mining practice will result in a serious reduction in strength.

Finally, it is to be noted that the conclusions arrived at are based on the results of tests on unseasoned material.

SUMMARY.

The paper describes a comprehensive investigation of the characteristic strength properties of seven species of home-grown softwood with reference to their use as supports in the mines.

A description of the experimental material, its selection and preparation for test, and the technique of testing is given, and the quality of the pit-props, their failure under test, and their relative strengths are discussed. Statistical methods have been employed as an aid to the interpretation of results and frequency diagrams are included to illustrate the variability of the strength of the props.

The strength of each species has been related to its physical characteristics and natural defects. Strength differences are found to exist between consignments of the same species taken from different localities and these are ascribed to differences in specific gravity or rate of growth, or to a combination of both these physical characteristics. The relationship between specific gravity and prop strength for each species is shown to be definite and may be regarded as fairly close; that between rate of growth and prop strength indicates that all species have an optimum growth condition. It is pointed out that within broad limits rate of growth may be taken as an index of density. The measurement of bow or initial curvature and its influence on prop strength is discussed, and emphasis is laid on the considerable reduction in strength arising from the incidence of this defect. Knot-whorls are not, apart from consideration of ease in handling and appearance,

TABLE VIII. *Particulars of Habitat*

Species	*Cons. no.*	*Locality*	*Stand*
European larch			
Pre-thinning	11/9–12	Drummond Hill Forest (Central Scot.)	Pure
Normal thinning	11/13–16	Drummond Hill Forest (Central Scot.)	Pure
	3/1–4	Abbotswood, Forest of Dean (W. Eng.)	Mixed
Japanese larch			
Pre-thinning	4/5–8	Gwydyr Forest, Denbighshire (N. Wales)	Pure
Normal thinning	4/9–12	Gwydyr Forest, Denbighshire (N. Wales)	Pure
	3/5–8	Abbotswood, Forest of Dean (W. Eng.)	Pure
	5/13–16	Allerston (NE. Eng.)	Pure
	12/1–4	Dalbeattie Forest (S. Scot.)	Pure
Norway spruce			
Normal thinning	3/9–12	Abbotswood, Forest of Dean (W. Eng.)	Pure
	5/9–12	Kielder Forest (NE. Eng.)	Pure
	4/1–4	Kerry Forest (W. Eng.)	Mixed
Sitka spruce			
Normal thinning	3/17–20	Staple Edge, Forest of Dean (W. Eng.)	Mixed
	5/5–8	Chopwellwood Forest (NE. Eng.)	Pure
	10/21–28	Inchnacardoch Forest (N. Scot.)	Pure
	8/1–4	Lake Vyrnwy (NW. Eng.)	Pure
Scots pine			
Pre-thinning	11/1–2	Alltcailleach Forest (E. Scot.)	Mixed
	6/1–4	Brockenhurst, Hants (S. Eng.)	Pure
	12/5–8	Dalbeattie Forest (S. Scot.)	Pure
Normal thinning	11/5–8	Alltcailleach Forest (E. Scot.)	Pure
	6/5–8	Brockenhurst, Hants (S. Eng.)	Pure
	9/5–6	Swaffham (E. Eng.)	Mixed
	10/17–20	Longart Forest (E. Scot.)	Pure
Corsican pine			
Pre-thinning	4/13–16	Delamere Forest (NW. Eng.)	Pure
Normal thinning	4/17–20	Delamere Forest (NW. Eng.)	Pure
	8/9–12	Alice Holt Forest, Hants (S. Eng.)	Pure
	3/13–16	Abbotswood, Forest of Dean (W. Eng.)	Pure
	9/7–8	Swaffham (E. Eng.)	Mixed
Douglas fir			
Pre-thinning	10/1–8	Portclair Forest (N. Scot.)	Pure
	11/17–20	Durris Forest (E. Scot.)	Pure
Normal thinning	10/9–16	Portclair Forest (N. Scot.)	Pure
	11/21–24	Durris Forest (E. Scot.)	Pure
	5/1–4	Chopwellwood Forest (NE. Eng.)	Pure
	8/5–8	Lake Vyrnwy (NW. Eng.)	Pure

of great importance. Any loss in strength with increase in knot/circumference ratio up to about one-third is ascribed mainly to reductions in specific gravity.

The results of tests on small test pieces free from defects, taken from the pit-props, show that the props of each species with a ratio of length to least diameter of 12 have upwards of 80 to 90 per cent. of the maximum compressive strength of the clear timber. The results of a further series of supplementary tests show also

of all Consignments of Pit-props

Planted	*Felled*	*Soil*	*Elevation (feet above sea-level)*
1912–14	Oct. 1941	Solid, freshwater alluvia—boulders and clay	500–700
1912–14	Oct. 1941	Solid, freshwater alluvia—boulders and clay	500–700
1916	Sept. 1941	Loam, good depth—red sandstone, surface boulders	450–610
..	May 1942	Shallow, light sandy soil	250–600
..	May 1942	Shallow, light sandy soil	250–600
1916	Sept. 1941	Loam, good depth—red sandstone, surface boulders	450–640
1923	Sept. 1942	Calcareous grit—good depth, badly leached	350
1924	Sept. 1941	Well drained sandy soil—on gravel and boulders	250–300
1905	Sept. 1941	Deep sandy soil	400–800
..	Feb. 1942	Sandy	700
1897	April 1942	4 in. humus and peat over light soil with boulders	1,600
1920	Sept. 1941	Poor shallow soil over limestone	400–600
1908	Jan. 1942	Sandy loam over sand to a stiff clay	300–350
..	Mar. 1942	Loam on clay—3–4 in. covering peat	..
..	April 1942	Clay loam	1,300
1931–2	Oct. 1941	6 in. black gritty loam over gravel bed	750
1916	May 1942	Sandy loam on gravel	180
1924	Sept. 1941	Well-drained black peat on granite	100–125
1883	Oct. 1941	2 in. humus on sand and gravel of alluvium	700
1920	May 1942	Sandy loam on gravel	170–190
1926	Sept. 1941	Sandy loam	600
..	Dec. 1941	Layer of peat on gravel subsoil with boulders	400
1923	June 1942	Sandy	300
1923	June 1942	Sandy	300
1920	June 1942	Layer peaty, sandy loam on gravel clay	300–350
1906	Sept. 1941	Loam—red sandstone surface boulders	400–600
..	Sept. 1941	Sandy loam	150
1924	Oct. 1941	Loam	100
1903	Nov. 1941	Shallow brown loam, stony—occ. rock out-crop	300
1924	Oct. 1941	Loam	100
1903	Oct. 1941	Shallow brown loam over drift	300
1908	Jan. 1942	12 in. sandy loam over sand and stiff clay	300–350
..	April 1942	Clay loam	1,300

that there is a gradual diminution of strength with increase in slenderness ratio.

When of good quality most of the home-grown softwoods compare favourably in strength with material from the Baltic and elsewhere. Attention is drawn to the comparatively low strength of the poorer quality material from wolf trees (fast-grown individuals taller than the average), and it is recommended that these should not be used for supports in the mines.

Evidence is provided to show that by means of selection, involving the rejection of all material with excessive bow or fast-grown and low in specific gravity, the quality and strength of props of all home-grown softwoods is improved.

ACKNOWLEDGEMENTS.

The work described above was carried out as part of the programme of the Forest Products Research Board and is published by permission of the Department of Scientific and Industrial Research. Thanks are due to the Forestry Commission for their valuable co-operation in providing the material for test.

LITERATURE REFERENCES.

(1) Armstrong, F. H.: 'Further Tests on the Effect of Progressive Decay by *Trametes serialis* on the Mechanical Strength of the Wood of Sitka Spruce.' *Forestry*, 1935, ix. (1).

(2) Beare, Prof. Hudson: 'An Enquiry into the Suitability of Scottish-grown Timber for Aeroplane and Pit-prop Purposes.' *Trans. R. Scot. Arb. Soc.* 1922 and 1924, xxxviii.

(3) Booth, F. J.: 'The Strength of Pit-props.' *Trans. Instn. Min. Engrs.*, 1918, lv. (1), 87–8.

(4) Bowen, J. W.: 'The Suitability of Supports Used Underground on the Watersrand.' *S. Afr. Inst. Engrs.*, 1941.

(5) British Standards Institution: *Methods of Testing Small Clear Specimens of Timber.* B.S. 373 (1929).

(6) Chaplin, C. J.: *Some Mechanical and Physical Properties of Timber Pit-props.* Bull. For. Prod. Res. Lond., No. 9, 1931.

(7) Dixon, S. M., and Hogan, M. A.: *Tests on Timber Pit-props.* Pap. Safety Min. Res. Lond., No. 72.

(8) Fisher, R. A.: *Statistical Methods for Research Workers.* London: Oliver and Boyd, 1930.

(9) Louis, Prof. Henry: 'The Strength of Pit-props.' *Trans. Instn. Min. Engrs.*, 1898, xv. 343.

(10) Robertson, Andrew: 'The Strength of Struts.' *Sel. Engng. Pap. Inst. Civ. Engrs.*, No. 28, 1925.

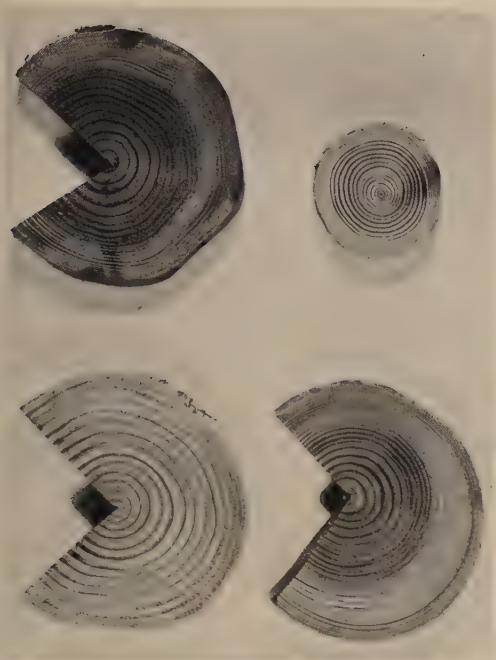


FIG. 4. Disks from Douglas Fir Props showing variation in rate of growth

FIG. 12. European larch (normal thinnings) from Drummond Hill Forest (E. Scotland)

FIG. 13. Japanese larch (normal thinnings) from Gwydyr Forest (Wales)

FIG. 14. Norway spruce (normal thinnings) from Kielder Forest (N.E. England)

PLATE V

Fig. 15. Sitka spruce (normal thinnings) from Chopwellwood Forest (N.E. England)

Fig. 16. Scots pine (normal thinnings) from Alltcailleach Forest (E. Scotland)

Fig. 17. Corsican pine (normal thinnings) from Delamere Forest (Wales)

Fig. 18. Douglas fir (normal thinnings) from Durris Forest (E. Scotland)

PLATE VI

UTILIZATION OF HOME-GROWN LARCH IN GREAT BRITAIN

(*Larix decidua* Mill. syn. *Larix europaea* DC.)

By JOHN T. SMITH

INTRODUCTORY.

LARCH in Great Britain is not indigenous but has been widely cultivated in all parts of the country. In one instance in 140 years a British larch stem grew to 6 feet in diameter at the base and contained 792 cubic feet, Hoppus, over bark, a notable result. Much has already been written about the European larch as grown in Great Britain, but in this paper an effort is made to co-ordinate the facts available and present them in the light of experience gained during the recent war of 1939–45.

It has been claimed that when grown in Great Britain under proper conditions in suitable soil larch produces more valuable timber per acre than any other tree. Yet in 1943 the Forestry Commission (12) said: 'Larch has been valuable in large sizes and in certain categories of mining timber but in other respects is no more valuable and often less adaptable than pine and spruce.' This provisional estimate of war experience of larch was made before the demand for home-grown timber had reached its peak, and before the period of intensive direction by licence of home timber into almost every market for which imported softwood timber had previously been used. Later, when it was apparent that supplies of softwoods were dangerously low, it became necessary to increase the use of home-grown hardwoods. As a result, particularly in Scotland, it became the custom, rightly or wrongly, to regard larch as a hardwood. Subject to price control, the practice was condoned by those in authority. In the price-control orders issued during the war no distinction was made between European, Japanese, or hybrid larch. Generally speaking, there was a price distinction in favour of larch, over pine and spruce, varying from 12½ to 25 per cent., but in the earlier months of the war, when timber was at first in comfortable supply, it was exceedingly difficult to persuade users to accept the higher-priced larch as a substitute for the cheaper softwoods. Later there was no alternative. The war is therefore, perhaps, not the most suitable period on which to assess the true qualities of home-grown larch.

In claiming that larch has the greatest range of use of all conifers in this country, from the tip to the root, including the bark and the sawdust, it is necessary to give some indication of the timber and its characteristics. Prior to 1939 the literature on this subject, though far from complete, was quite imposing. Both the Forestry Commission and the Forest Products Research Laboratory, Princes Risborough, had made their contributions. There was, however, no combined effort on the part of the growers, the trade (with generations of

experience), and the technical foresters to produce documentary evidence on the availability of supplies and sizes of larch and its selling qualities. The curtailment by the war of the activities of the National Home-Grown Timber Council put an end to the possibility of such a combined effort. In 1939 it was overdue. Had it been available it might have altered much of the war use of larch.

Before discussing British practice it is useful to refer to practice elsewhere. Turning to western countries for inspiration it is found that in 1937 the Western Pine Association of Oregon issued a most attractive book, entitled *Larch, its Properties, Uses and Grades* (18). Reliable sources of information were used in its preparation, including authoritative data supplied by Federal and State Governmental Agencies. The trade association had its own Research Laboratory, set up in 1925. Full use of facts and figures was made in the book. As is usual with American publications, it was superbly illustrated and covered the whole field of manufacture and supply, the characteristics and properties, and the requirements for specific uses, together with very definite recommendations of grades of larch for specific uses. In this case the species was *Larix occidentalis*. The total stand of this timber in the Columbia River basin area was stated to be 25 billion feet (board measure), and the average annual production of the order of 10,000,000 cu. ft. (120,000,000 feet board measure).

QUANTITIES AVAILABLE IN GREAT BRITAIN.

The Forestry Commission of Great Britain followed up their Report on Census of Woodlands and Census of Production of Home-Grown Timber, 1924, by a supplementary report (13) in 1930 (published in 1932, 70–9999) which gave the production of larch in Great Britain in the year 1930 as follows:

	Cu. ft.
Timber of sawmill size . . .	3,883,000
Smaller material (pit-props, &c.) .	1,768,700
Firewood	10,000
Other wood (hop poles, &c.) . .	473,400
	6,135,100

The total production of all conifers at that time was given as 26,405,400 cu. ft., so larch represented just over 23 per cent. of the total. So far the consumption of larch during the war of 1939–45 has not been disclosed, nor is it known by the writer whether such separate information will ever be available. There is need, obviously, for a completely new census of the supplies available for industrial purposes. Two-thirds of the available supplies at the outset of the war are said to have been consumed. Until, therefore, the cleared areas have been replanted with thriving crops of timber beyond the first thinning stage it may be premature to suggest the development of selling propaganda; but it may be of importance to foresters to examine in some detail the known uses of larch in this country, in an attempt to assess the desirability or otherwise of increasing the supply. (A good documentary film of the principal and important uses of larch might well be made now for reference when crops become available again.)

GENERAL DESCRIPTION.

Described by the Forest Products Research Laboratory, Princes Risborough, as the most valuable, hardest, and toughest of home-grown softwoods (disregarding yew), larch timber has a wide range of colour, from yellow or yellow-brown sapwood to reddish-brown and brick-red heartwood (7). The heartwood is resistant to decay while the sapwood is not durable. Larch is heavier than other British softwood timbers. Transport charges are correspondingly higher per cubic foot when carried at machine weight. The timber is slightly more difficult to saw, both at felling and in the mill. The timber from the outside trees of a forest is particularly liable to spring, i.e. curvature of a board or plank in its own plane. The successful utilization of the timber is therefore very much a matter of the skill of the saw-miller in cutting the timber according to its particular use, and according to the market prices for the finer qualities. The Laboratory has produced a number of bulletins and progress reports detailing the results of tests of home-grown timbers in their green and seasoned condition, and has described the uses and characteristics of larch. The mechanical and physical properties are compared with those of other softwoods. There is no need, therefore, to refer to these results in detail here. They are available in the publications listed at the end of this article. In some of the tests the superiority of Scottish-grown over English-grown larch will be observed.

USES (FROM TOP TO ROOT).

A. Thinnings.

For the convenience of foresters and because of the need for dealing with young woods and thinnings in the first place, it is proposed in this article to discuss the various uses, commencing with the top of the tree and working downwards to the root. This is the opposite of the more usual method of the timber merchant who makes the most of butts and leaves the upper part of the tree for the secondary and less valuable markets. It must not be inferred that it is always possible to dispose of the upper part of the tree profitably. As will be seen, the markets are available, but their distance from the forest in a number of cases may cancel out the profits.

(*a*) *Needles and Branches.* Larch needles are particularly rich in potash and the tree is therefore considered by some as among the soil improvers. The branches with their bright green buds in spring are sufficiently decorative to be worth marketing locally if they can be removed without silvicultural damage.

(*b*) *Rustic Work and Use of Thinnings.* No other conifer grown in Great Britain has so wide a range of use (3, 17) in all sizes, particularly in the earlier and middle-age classes, as shown by the following specifications. In favourable situations the tree is fast growing and can reach a height of from 35 to 45 feet in 20 years. The Forestry Commission recommend the first thinnings from a normal plantation when the dominant trees have reached a height of 30 feet. The earlier thinnings as well as the tops of well-grown older trees are immediately useful in sizes from 1-inch to 1½-inch diameter (at the small end) and up, in all lengths, for rustic poles and pergola and trellis work, and for an infinite variety of pole and spar

purposes for agricultural and horticultural work in all parts of the country (flower, bean, hop, fruit and sheep net stakes, fencing droppers, &c.). The durability of larch in younger wood is probably at least twice that of Scots pine, spruce, or Douglas fir. It is tough, strong, and lasting, and when young does not warp or twist to the same extent as does older wood. The development of these uses has not been exhausted. Rustic garden furniture, tables, chairs, seats, gates, porches, plant-boxes, bird-boxes are examples of existing uses which can readily be expanded.

(*c*) *Mining Timber.* On account of form of stem but mainly because of strength, larch is specially suitable for pit-prop production (9). The round mining-timber market is capable of absorbing every diameter size from 2½ inches and up, to at least 7 or 8 inches at the small end, in lengths from 2 feet to 14 feet or more, rising by half-foot or foot stages. The sawn mining-timber market could absorb practically everything grown in larch in this country. The offcuts and badly grown material can be converted into saleable sawn products so long as this market is available. Very complete details of specifications used in the pits are to be found (11) in the report (Utilization Series No. 2) on the demand for timber in coal-mining in England and Wales, published by the Forestry Commission in 1935. There is no need, therefore, to discuss this market in further detail here, except to say that the war opened up the demand for larch to practically every size of timber used in the pits, including in some cases special sawn sizes in substitution for pitch pine. Larch poles and props have been used regularly in the shale- and also the iron-mines for upwards of 50 years. In the case of one group of iron-mines, so much reliance is placed on larch that Scots pine and imported redwood (imported Scots pine) poles are substituted only in larger diameter sizes. Spruce is refused. A certain amount of substitution of steel for wood is regarded as inevitable in the mines, but the market is such a large one that there is room for all home-timber production so long as there are mines. A selection of prop sizes will be found in the appendix to this article.

(*d*) *Charcoal.* During the war larch was tried out in charcoal production and some of its products were used in penicillin-making and navigational lighting. Suitable dimensions have been stated as 18-inch lengths, with a range of from 2 inches minimum to 8 inches maximum diameter.

(*e*) *Paper-making.* The introduction of larch to the paper-mills has not been successful. The report from one very large group of mills in England is that 'larch is a bad paper-making timber because of its hard short cellular fibre'. The resin content also is troublesome. As much of the larch received during the war was affected by canker, it was found to be of little use. The chemist of the same paper-making group gives the following report:

'In the first place the general "untidiness" of larch, as well as the resinous extrusions, cause it to be disliked for paper-making purposes. It is heavy, hard and coarse-grained wood which responds best to sulphate treatment, which produces a reasonably good kraft pulp. As ground-wood it has a dirty greyish-green colour. The unequal distribution of resin in this timber makes it unsuitable wood for our process—the sulphite process—and is the cause of a good deal of chips and shives.'

It is perhaps unfortunate that the priorities for timber during the war were such that the paper-mills had to be content with rough offcuts from the forest which were carried long distances in a green and unpeeled condition. The peeling had to be undertaken after delivery at the mills. It says much for the patience of the paper industry that in place of selected and sized, peeled and dried softwood logs they absorbed so much poor quality home-grown timber, which because of low quality and high expense must have done much to damp down any enthusiasm for home-grown timber. On the other hand, the greater use of pine and spruce for paper-making ought to stimulate the demand for larch for other purposes.

(*f*) *Bark.* In all of the foregoing uses the removal of the bark before dispatch to the consumer enhances the value of the timber, increases its life and durability, and improves the reputation of home timber. There was at one time in this country a very definite market for larch bark (from the main stems only), which more than compensated for the cost of peeling and improved the selling value of peeled timber. That market disappeared after the First World War but was available again during the Second World War. Unfortunately, proper advantage of the market could not be taken, as little or no labour was available for peeling. There was, however, a certain amount of production. Possibly there could again be a market for larch bark, particularly with the development of the manufacture of compressed fibre boards, one or other of which may require it as a special basis. It is a matter of importance in the case of larch to consider carefully this question, because in larch the percentage of bark in the over bark volume is the highest of all the conifers grown in Great Britain. According to the Forestry Commission yield tables, published in 1946, the percentage of bark in European larch varies from 18 in Quality Class I to 22½ in Quality Class V, while in Japanese larch the percentage is 16 to 17½ in Quality Classes I and II. It will be observed that the percentage increases in the poorer quality classes. The trade practice in Scotland of allowing 10 per cent. for bark, both in buying and selling, and in England 7½ per cent., seems to be due for revision. (The Forestry Commission have confirmed by tests that the percentage of bark is actually higher in the case of larch grown in Scotland.) A purchaser in Scotland who buys 100 cu. ft., over bark, of European larch, unless he makes a very detailed examination of the trees purchased, pays timber price for 90 cu. ft. but according to the yield tables receives only 80 cu. ft. If he makes peeled pit-props or telegraph-poles, he has to recover in the selling price for the peeled timber a price per cu. ft. which may lead to much misunderstanding on the part of the growers. Whether there is or is not a market for bark, it is quite clear that home-grown pit-props will never retain a permanent share of the mining-timber market unless they are supplied in a peeled condition.

B. Pole-trees.

(*g*) *Poles.* It is probably in the use of larch for poles that there has been most research in the past.

The railway companies and the Post Office have always been users of larch poles but have expressed a preference for home-grown Scots pine or imported redwood (Scots pine) poles, on the ground that larch poles are liable to check or

split severely, with consequent danger to the linesmen who have to climb the poles with climbing-irons. During the war they had, however, to return to the use of larch on an extended scale. The Post Office issued a relaxed specification to meet war-time conditions which, in theory at any rate, was very suitable for home larch but was interpreted by the pole inspectors in different parts of the country in as many different ways.

In a paper read before the Royal Scottish Forestry Society by Mr. R. G. Bennett (2) of H.M. Post Office in February 1934, he gives his experience of larch poles as quoted in full below:

'In spite of the unfortunate experience of the private Companies, the Post Office did not cease until 1923 in its attempts to make larch tractable. It was never possible to inject more than 6 lbs. of creosote per cubic foot, and the process took more time and cost more than to inject twice that quantity into Scots pine. After all the trouble, the poles in service developed deep and wide shakes which endangered the lives of men climbing by means of spurred irons, and opened up the inner wood to fungal attack. Sometimes the shakes developed spirally and threw the head of the pole out of alignment. A parcel was seasoned under bark before treatment, but in five years their condition was not better than larch seasoned in the usual way.'

It seems unfortunate that a treatment to overcome this tendency to shake has not been found, particularly as laboratory tests show that under certain conditions larch telegraph-poles are 30 per cent. stronger than imported Scots pine of the same dimensions and the same moisture content.

In 1931 the Forest Products Research Laboratory, Princes Risborough, issued Bulletin No. 8, dealing with the use of home-grown larch poles for transmission lines (10). This report covers the whole range of seasoning and creosoting of larch poles, including the incising process, and also much information on the mechanical tests of the strength of treated and untreated poles. The British Standards Institution in 1933 issued B.S. No. 513 for European larch poles for transmission lines (4). The specification includes three tables, covering light, medium, and stout poles (see Appendix). The standard specification prescribes the treatment prior to creosoting, and the methods of creosoting, and gives statistical data on the ultimate breaking-loads of larch poles.

During the recent war the supply situation was such that there was once more a greatly expanded use of larch for telegraph- and transmission-poles, as well as in the many special war demands for light telephone-poles, for obstruction-poles against the landing of enemy aircraft, for ladder-poles for Air Raid Precautions work and for scaffold-poles; also for masts carrying lights at aerodromes, and very tall masts in several tree-lengths (joined together) for radiolocation centres. (Masts for carrying aerial-wires for radio reception are a popular use.)

The range of specification of all these poles varied from 16 feet and up in length and 2 inches and up in diameter, and the demand for many of the sizes should continue in peace-time. There is in particular a strong demand now for transmission-poles required for the many electricity schemes throughout the country. It is unfortunate that many of the finer stands of larch have had to be sacrificed for war purposes.

Other examples of the use of larch poles locally are, of course, well known. The use of larch poles in shipyard work is referred to elsewhere in this article. One small local use is for poles for drying salmon or other fishing-nets, a popular specification being 19 feet long by 3-inch top diameter, and shorter pieces of similar thickness for cross-spar purposes. Another limited market for larch poles is in tennis-court surrounds, using 11-foot to 15-foot lengths by 2-inch to 2½-inch tops.

C. Saw-logs.

(*h*) *Saw-mill timber.* All the foregoing purposes are suitable for timber up to, say, 7 or 8 inches quarter-girth. In the case of larch timber of any size which because of its condition of growth or shape cannot be used in the round as props or poles, &c., much of it can be converted in the saw-mill. The produce is suitable either for mining timber, in the case of the smaller logs, or in the case of larger or better quality logs for more attractive markets in competition with other softwoods. This wider market will not disappear when imported timber becomes plentiful again, but the lower price of other conifers may have to be accepted. The quantity of timber regularly available determines the size of the mill to be used, but the sizes of the logs determine the uses. There is much loose opinion in Great Britain on the size of log to be grown for saw-mill work. Generally speaking, the smaller the log the heavier the cost of and the loss in production. This is true even though the quality of large and small logs be identical. The aim should be, of course, the maximum quantity of logs of uniform size. In Finland the average length of saw-logs of softwood has been for many years 17–19 (English) feet, and the average diameter 7–8 (English) inches, with a minimum diameter of 5 inches at the small end, under bark. Such logs are well within the scope of forestry in Great Britain. Smaller logs tend to have more knots than larger logs, but except for trees which are grown for special quality work there is little need nowadays to aim at the size of timber produced on the west coast of America. Concrete and steel may be able to supply some of the heavier dimension sizes, and laminated or built-up dimensions in timber are the order of the day. The exception is, of course, for plywood and veneer logs. There is little to show that there will ever be any considerable demand for larch for these purposes.

(*i*) *Fencing.* A well-established market for larch is to be found in fencing, whether for farm, estate, or garden work. Local authorities specify larch with confidence. Railway companies are willing to use it to the extent it is available. The specifications vary according to local use, from the common farm 'stob' in Scotland, in lengths of 4 ft. 6 in., 5 ft., and 6 ft. or longer, cut from 6-inch, 7-inch and 8-inch top diameter logs, quartered and pointed at the heavier end (peeled or unpeeled), to square-sawn posts cut from heavier logs, particularly those with heart rot. European larch drives much more easily and shows fewer defects after driving than any creosoted redwood. Rails, straining- and gate-posts, gates (field and wicket), droppers, stays, and pegs, treated with preservative or untreated, are all in wide use. The railway companies have their own specifications, vide the Appendix.

(*j*) *House-building and Constructional Work.* For house-building and constructional work generally, larch has possibly not had a fair trial in Britain. Producing a high average of cylindrical stems the tree is suitable for economical conversion in long lengths. The difficulty of conditioning the timber concerns the grower as much as the impatient producer. Time and again larch has been found in use on estate buildings, in rafters, beams, and sarking, to say nothing of panelling. Its possibilities for flooring or paving-blocks do not seem to have been exploited sufficiently. Edge-grain larch is obviously in its rightful place for these purposes. Appreciable quantities of larch rails, 4 in. × 2 in. in lengths 10 ft., 12 ft., 14 ft., and 18 ft., have been produced at forest mills for fencing-rails. These same sizes happen to be building-timber sizes in strong demand. The fencing market has always until the war bid more for this timber than the building trade. Perfectly serviceable flooring can be made with sawn larch, the knots being no disadvantage so long as they are sound and tight. Small-dimension larch, i.e. narrow in width and short in length, is particularly suitable for this work. It is generally admitted that larch is not a suitable wood for bending. With care it can be machine-dressed and planed satisfactorily. It can be successfully kilned and if reduced to the appropriate moisture content for the purpose remains in place without swelling or shrinking. Grading rules for the strength of larch have been dealt with in Leaflet No. 19, dated 1941, issued by the Forest Products Research Laboratory, Princes Risborough (8). The British Standards Institution in the same year issued B.S. No. 940, with grading rules for structural timber, including larch, based on an extreme fibre stress in bending ranging from 800 to 1,200 lb. per sq. in. (5).

(*k*) *Wood Wool.* During the war home timber had to supply some of the demand for wood wool which was required in shell-making and also in packing delicate machinery parts. Twenty-five per cent. of the timber supplied was larch, which had to be peeled and was supplied in short log lengths, rather heavier than pit-prop size.

(*l*) *Firewood.* Larch is said to be an indifferent firewood owing to its tendency to spark. In log billets this is less noticeable than in sawn offcuts. It makes a hot fire if suitable precautions are taken. It burns well with a lively and somewhat noisy flame. Resin is expelled by the heat.

(*m*) *Sawdust.* Larch sawdust is used for most of the ordinary purposes for which any softwood sawdust is suitable, such as fish-curing, stabling, manufacture of compressed firelighters. One special use is disclosed in recent experiments in treating soil by spreading a light protecting surface on ground which it is not intended to dig. This seems contrary to all previous horticultural knowledge, but it is claimed that frost is excluded from the ground and that it is kept immune from attack by caterpillars, &c. It may be, of course, a coincidence that larch sawdust happened to be available when this experiment was conducted. Until there are plentiful supplies of saw-mill logs it will not be possible to establish that larch sawdust has any special virtue for compressed boards, plastics, &c.

(*n*) *Turpentine.* There does not seem to be any record of the tapping of mature larch-trees for turpentine in Great Britain.

D. Special Uses.

(*o*) *All-weather Purposes.* Experience (16) bears out the undeniable qualities of larch for outside use in all weather conditions in the north temperate zone. Bridge-building, weather-boarding, breakwaters, dock-gates and sluices, piers, agricultural implements, wireless masts, railway sleepers, railway wagons, cart and lorry work, wheelbarrows, feeding-troughs, field and garden gates, fencing of all kinds in the round or sawn, poultry- and garden-stakes, and straining-posts are all well-tried examples. The timber, particularly the heartwood, does not creosote well but can be incised and creosoted. As quoted above, on poles, the Post Office experience of creosoting showed a maximum penetration of 6 lb. per cubic foot. In a paper read before the British Association in 1930 by Mr. J. Bryan (6), Forest Products Research Laboratory, Princes Risborough, it was stated that under pressure very little penetration can be obtained in the heartwood of larch and little more than 2 to 3 lb. per cubic foot absorption occurs. With incising, the penetration has been stated as 10 to 12 lb. per cubic foot. The tendency to check (particularly in the sapwood, if peeled) and to warp and twist, attributable by some to the soil in which the tree has grown, are difficulties which are well known and can be overcome to some extent by treatment during conversion and preparation. The seasoning of the log in the unpeeled state, the cutting of thick planking, sawn through and through and unedged, to be air-seasoned before being resawn into smaller dimensions, are suggested ways of reducing the trouble. Perhaps the surest solution is the controlled growth of the tree to give even grain and the minimum number of knots. Much research is still indicated, in all directions. One method suggested by some writers to prevent checking and warping is not attractive to timber merchants who have to contract to fell and remove trees quickly. It consists in ringing the bark at the base of the tree and leaving it standing for one or more years before felling.

(*p*) *Shipbuilding.* It is in boat-building and dock work that home-grown larch has its most important market in Great Britain. Here it is unsurpassed, and imported timber is substituted only where regular supplies of larch have failed. Foresters who may have given up hope of a future for European larch would do well to study the requirements of this market most thoroughly before deciding to abandon the species. Japanese or hybrid larch, however attractive as crops, have not so far convinced the users in this market that they can take the place of European larch as grown here. The story of the demand for timber in shipbuilding and in docks and harbours has already been told very thoroughly and attractively in Utilization Series No. 4, published for the Forestry Commission in 1938 (14). There is to be found evidence of the popularity of larch in the Government dockyards and in those owned by the railway companies and the local authorities. In shipbuilding and repairing, and in boat-building, in passenger, cargo, pleasure, and fishing-vessels of every description will be found larch, taking its proper place alongside as well as in preference to other timbers. The shoring-poles which supported the hulls of the *Queen Mary* and the *Queen Elizabeth* and other famous vessels; the salmon cobles at Aberdeen, Berwick-on-Tweed, and possibly elsewhere; the heavy rowing-boats on Loch Leven, so well known to

anglers, the drifters and seine net fishing-boats, the dinghies and the ships' life-boats, the countless pleasure-boats—all have or could have their quota of larch planking, boarding, sparring, and framing; while deck beams, hatch covers, piling, bridge guards, fencing, lock-gates and fenders, repairs to barrows, boats, and lorries, are all recognized uses.

The characteristic sweep of the larch-tree as it often grows on the hill-sides is of great advantage to boat-builders. Such logs must be cut on band or frame saws to retain the curve in the plank or skin produced. Thwarts and knee bends can be obtained from the junction of the root and the stem. This is no new discovery. Such uses are described in detail in *The Larch* by Michie (15), published in 1885, and again in the Forestry Commission publication of 1938 referred to above. The possibility nowadays of more economic root extraction by the use of bulldozers, where the hill-sides are not too steep, may help to develop this market, which is still there for those who take the trouble to cater for it. The root of the larch tree is very obliging for this purpose. Two or three feet of the main stem must be left after felling and a similar length of single root retained with this stump.

During the war of 1939–45 the standard larch boatskin log specification for the construction of Admiralty boats required lengths of 16 feet and up, although some shorter lengths could be used. The logs had to be a minimum of 8 inches quarter-girth at centre and reasonably clean and free from black knots. For the thin 'skin', i.e. under 1 inch thick, exceptionally clean logs were required, but for the heavier planking the specification was naturally not quite so strict, except in regard to lengths which were often required 25 feet and up. Prices were accordingly made attractive to suit these somewhat severe specifications.

An attempt was made by the writer and his staff at the Ministry of Supply to define the requirements of larch boatskin logs used for the production of 2½-in., 3-in., and 4-in. planking. The lengths had to be 24 to 45 feet and extracted in the longest possible lengths. The cutting of a 50-foot into two 25-foot lengths was not recommended. One-way sweep was preferred, but straight logs were acceptable. 'S' bends were of no use and trees with kinks were similarly rejected. The normal boatskin tree had to be comparatively clean for 80 per cent. of its length. The number of knots was severely limited. The bottom half of the tree had to have no knots or practically none. All knots had to be sound. None could exceed 3-inch diameter. Loose knots entailed rejection. Rot in the centre of the log did not necessarily cause rejection, as planks could often be taken on either side of the rot. Rot in the rings disqualified a log until cross-cut back enough to eliminate the rot. Felling splits were not permitted.

(*q*) *Railway Work*. To the railway companies larch is a most important timber. Its use by them was extended during the war to many fields in which it had been previously used but discarded in favour of cheaper imported timber available in normal times. Such items as sleepers (see war-time specification in the Appendix), cut from logs of 12 or 13 inches diameter at the small end and up, to give the standard size 8 ft. 6 in. × 10 in. × 5 in. and many others in shorter or longer lengths, and wagon wood, both bottoms in 7- to 8-foot lengths and sheeting in

longer lengths, mostly in 2½-inch plank, in widths of 5 inches or more, and varying lengths, are instances of use in considerable quantity. Sheeting of 4 in. × ⅞ in. for platforms, lamp-posts of 6 in. × 4 in. in varying lengths, and fencing spars, posts, and rails in varying specifications were all acceptable in larch. So were gate-posts of 6 in. × 6 in., 7 in. × 7 in., and 8 in. × 8 in., in varying lengths; and fence-posts of 6 ft. × 6½ in. × 3¼ in., half-round, and 6 ft. × 3½ in. × 3½ in., square, with 9 in./10 in. points. The wagon wood and sheeting had to be air-dried for three months and was also subject to inspection before dispatch.

(*r*) *Other Uses.* So much for the well-known uses. Not so well known is the use for bed-spring framing or for glass houses and cold frames, clothes poles, and rafters. One very special use for prime quality larch has been found in the manufacture of vats in the distillery trade. Barrel heading is sometimes made of larch, and staves may also be of this species. In case-making the wood is not popular, but considerable quantities have been absorbed by the box-making industry. Crate-making, particularly for heavy export work, garden-path edging, and pegs, are popular uses. It is not adequately appreciated that larch offers great resistance to the withdrawal of nails and retains this characteristic during change of moisture content. In fencing work larch will hold staples much more firmly than creosoted timber.

In discussing larch many writers have drawn attention to the uses in past centuries and have recorded the employment of the timber in place of canvases for painting (Raphael's paintings are said to have been on larch). There is no doubt that some quality in the grain of the wood has attracted artists. Larch can be highly polished and is particularly suitable for french polishing. It is little used in turnery or in sculpture, probably on account of a tendency to shake. There must be many fields where the use of larch has not been tried but where it would establish instant success. One such instance came to the writer's notice some years ago when a much-harassed white lead manufacturer complained that the imported redwood (pine) or whitewood (spruce) which he had been using in his kilns had a very short life and was adding considerably to his costs of manufacture. He was recommended to use home-grown larch, which he did somewhat reluctantly but ultimately with outstanding success and considerable financial benefit.

E. New Uses.

(*s*) *Suggested New Use.* No attempt has been made in Britain to popularize knotty larch timber as has been done so successfully with other species in other countries. Much of the medium-sized larch grown in Britain at present would suit such a use. It cannot be developed until the trade is assured of a definite regular annual fall of timber, placed in the hands of those who have the appropriate plant for the purpose.

CONCLUSIONS.

Questions of the influence of altitude on the durability of larch and of the existence of certain better growing zones in Great Britain are rather beyond the

scope of this paper. That such zones exist has been recorded by Dr. Mark Anderson in the pages of the *Journal of the Royal Scottish Forestry Society* (1). It may also account for the preference of certain English users for larch grown in Scotland. There can be no doubt that the best larch is grown where the winters are long and severe. There have been frequent instances where users have continued to specify home-grown larch from districts where unfortunately the supply has already been exhausted. This rather suggests that one day in Britain it will be possible to copy the shipping-mark procedure of the importers, and identify the best home production by certain well-known marks of origin.

Refinements in marketing research have so far found no place in the programme of the native timber industry. On the other hand, considerable sums of money have been disbursed in the past by government departments for the marketing in Great Britain of exotic Empire timbers. Enough has been said to prove the existence of a very large outlet for home-grown larch of all sizes and age classes. It is true that there has been disappointment and difficulty in marketing some of the poorer quality timber, as larch; but even when markets were most depressed in the years between the wars it was always possible to sell such lower grades as ordinary softwood, if the higher price for larch was abandoned. (This is particularly important in the future of the mining timber market which should be retained for all suitable and available home timber.)

The markets described above have not all been tested with Japanese or hybrid larch. No attempt is therefore made on this occasion to describe the uses of these species. In practice the timber from them is thought to be generally inferior to that of European larch.

The fate of larch in the future rests with heavy responsibility on the forester, but the trade has a part to play. Marketing without the knowledge and skill of the trade will inevitably reduce the high value that larch has attained in the British markets, and this applies to the thinnings as well as to the mature timber. It is of some significance that each and every use of larch described in this paper owes its origin in the first place to the home timber trade; and this applies to war as well as to peace-time uses.

LITERATURE REFERENCES.

(1) Anderson, M. L.: 'The Silviculture of the Larches'. *Scottish Forestry Journal*, liv, Pt. 1, 1940, pp. 22–32.

(2) Bennett, R. G.: 'Telegraph Poles: their Production, Preparation and Preservation'. Ibid. xlviii, 1934, pp. 43–54.

(3) Boulton, E. H. B., and Jay, B. Alwyn: *British Timbers, their Properties, Uses and Identification*, Adam and Charles Black, London, 1944.

(4) British Standards Institution: *Specification for European Larch Poles for Transmission Lines.* B.S. 513—1933.

(5) —— *Grading Rules for Structural Timber.* B.S. 940—1941.

(6) Bryan, J.: 'Antiseptic Treatment of Home-Grown Conifers'. *Empire Forestry Journal*, ix, 1930, pp. 236–41.

(7) Forest Products Research Laboratory, Princes Risborough: *A Handbook of Home-Grown Timbers*, 1945.

(8) —— *Grading Softwoods for Strength.* Leaflet No. 19. 1941.

(9) Forest Products Research Laboratory, Princes Risborough: *Home-Grown Pit Props.* Bulletin No. 9. 1931.
(10) —— *The Use of Home-Grown Larch Poles for Transmission Lines.* Bulletin No. 8. 1931.
(11) Forestry Commission: *Demand for Timber in Coal Mining in England and Wales.* Utilization Series No. 2. 1935.
(12) —— *Post-War Policy.* Cmd. 6447. 1943.
(13) —— *Report on Census of Production of Home-Grown Timber.* 1930.
(14) —— *Report on the Demand for Timber in Shipbuilding and in Docks and Harbours.* Utilization Series No. 4. 1938.
(15) Michie, C. Y.: *The Larch*, Wm. Blackwood & Sons, Edinburgh and London. 1885.
(16) Smith, John T.: 'Durability of Scottish Larch'. *Scottish Forestry Journal*, xliv, 1930, pp. 55–9.
(17) —— 'The Utilization of Certain British Softwoods'. Ibid. l, 1936, pp. 93–102.
(18) Western Pine Association, Portland, Oregon: *Larch, Its Properties, Uses and Grades.* 1937.

APPENDIX

SPECIFICATIONS OF LARCH (*Larix decidua Mill.* syn. *Larix europaea* DC.) AS USED IN GREAT BRITAIN

Rustic Pergola and Trellis Work.

Posts cut to lengths 3½″ to 5″ dia. at butt, according to weight preferred.
Rails or spars 3″ dia. at butt.
Cut to lengths 2½″ dia. at butt.
Filling-in or ornamental pieces 2″ dia. at butt, in random lengths.
For all these sizes thinnings are sold in random lengths as felled, varying from 2″ to 5″ dia. at butt by not less than 1″ dia. at top.
Prices per ton, or per 100 lin. ft., according to local custom.

Mining Timber.

(*a*) *Round.* Common sizes of pit-props:

Dia. at small end U/B.	*Common lengths*
2½″	2′0″, 2′3″, 2′6″, 2′9″
3″	2′0″, 2′6″, 3′0″, 3′6″
3½″	3′0″, 3′3″, 3′6″, 4′0″
4″	3′6″, 3′9″, 4′0″, 4′6″
4½″	4′6″, 5′0″, 6′0″
5″	5′0″, 6′0″, 7′0″
5½″	5′6″, 6′0″, 7′0″
6″	6′0″, 7′0″, 8′0″

(*b*) *Sawn.* Common sizes of crowntrees, splits, sleepers, baulks:

Width	*Thickness*	*Common Lengths*
4″	2″	4′0″
5″	2½″	3′0″, 3′6″, 5′0″, 5′6″, 6′0″
6″	3″	3′6″, 5′0″, 6″0″
7″	3½″	6′0″

Coverboards

4′ and up, rising in 6″ stages
4″ and up, rising in 1″ stages
} by 1½″ and 1¼″

CHARCOAL.

Lengths: 18″. Diameters: 2″ minimum to 8″ maximum.
Peeled.

POLES FOR TRANSMISSION LINES.

	Lengths	*Diameters at small end*
Light:	16′ to 50′.	$4\frac{3}{4}$″ to 7″ under bark.
Medium:	24′ to 65′.	$5\frac{1}{4}$″ to 9″ under bark.
Stout:	26′ to 85′.	7″ to $10\frac{1}{2}$″ under bark.

FENCING-POSTS.

Round: 3″ dia. at small end and up—common lengths 4′6″, 5′0″, 5′6″, 6′0″. Pointed, not exceeding 18″ at heavy end.

Sawn: 6″, 7″, or 8″ top diameter, quartered and pointed—common lengths 4′6″, 5′0″, 5′6″, 6′0″. Pointed, not exceeding 18″ at heavy end; or square sawn $2\frac{1}{2}$″ by $2\frac{1}{2}$″; 3″ by 3″ and up, according to weight required and in varying lengths.

Straining- and gate-posts, round or sawn, according to weight required, 6″, 7″, and 8″ top dia. in lengths 7′0″ to 9′6″.

Stays, Struts } 3″ top diameter in lengths of 7′, 8′, 9′, and 10′.

Droppers: Cross-section 2″ × 2″ or in round equivalent.

Stack props: 2″/3″ top diameter, in lengths 8′, 9′, and 10′.

WOOD WOOL.

Short peeled log lengths, according to machines used, and in multiples thereof. Suitable specification might be: $6\frac{1}{2}$″ and up to 10″ or 12″ top dia., in lengths of 2′, 4′, 6′, 8′.

BOATSKIN LOGS.

Exceptionally clean logs with or without natural one-way sweep of the tree, 8″ quarter-girth minimum at centre of log.

Lengths 16′ and up (some shorter lengths accepted); maximum length 45′. See text for details.

HOME-GROWN SLEEPERS AND CROSSING TIMBERS (*Railway war-time specification*).

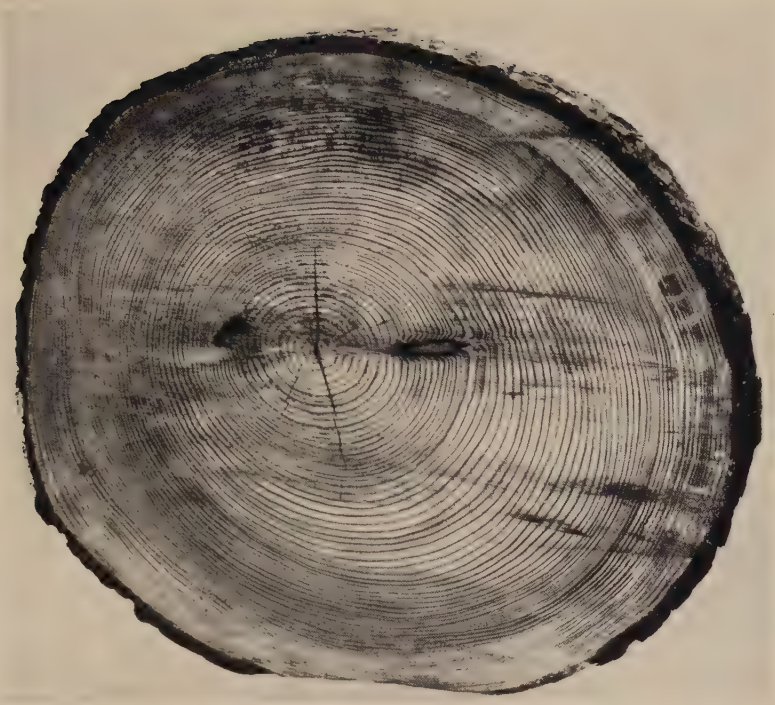
Covering the following:

Hardwoods: oak, beech, and elm.

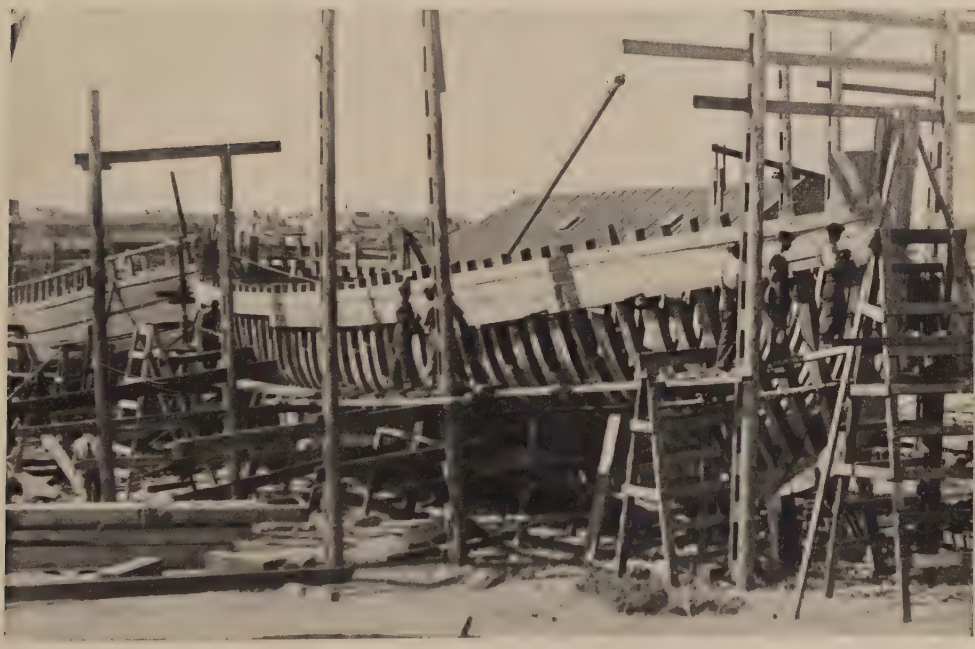
Softwoods: larch, Scots fir, spruce, Douglas fir, silver fir, silver spruce, Corsican pine.

The timber should be of good, sound quality, straight grained, i.e. should not deviate more than 1″ in 8″, free from shakes, large, loose and/or unsound knots, and large pitch seams.

If the heart centre be present it must not be more than 1″ from the wide surface. The annual rings rising from the heart face must terminate on the same face or on a narrow face. Not more than 10 per cent. of hardwood sleepers may be supplied with box hearts. No restriction placed on the percentage of box hearts in softwood sleepers. The term 'box heart' refers to sleepers in which the heart centre is farther than 1″ from either of the wide faces, and 'edge grain' is when the annual rings arising from the heart face terminate on the opposite wide face). Sleepers or timbers showing a box heart at one end but acceptable at the opposite end, if otherwise sound, shall be accepted.



Cross-section of typical European larch tree from Deeside, Aberdeenshire.
(*Larix decidua* Mill. syn. *L. europaea* DC.)



Construction of fishing-boat showing application of larch 'skin'.
Motor fishing-vessel, 75 ft. long, 31 tons net, June 1945.

PLATE VII

Sizes: Ordinary sleepers, 8′6″ × 10″ × 5″.
Joint sleepers, 8′6″ × 12″ × 5″.
Crossing timbers as specified, 12″, 14″, 16″, 18″ × 6″, in varying lengths, 8′ to 20′.
Slight toleration in lengths, widths, and wane. Must be stripped of bark.

Railway Sheeting for Repairs (*L.M.S. specification*).

14′8″ × 9″ × 2½″ }
15′0″ × 7″ × 2½″ } 10 per cent.
16′6″ × 11″ × 3″ 60 per cent.
17′6″ × 7″ × 2½″ }
18′0″ × 9″ × 3″ } 30 per cent.

To be sound, in clean bright condition, free from excessive sapwood, large or unsound knots, shakes, and decay. To be well sawn full to size, square on edges, but not more than 5 per cent. may have slight wane on one side face. Ends roughly squared if lengths cut full.

Railway Wagon Bottoms.

2½″ × 7″, allowing up to 40 per cent. in 5″, 5½″, 6″, and 6½″ widths, and in lengths 7′6″, 7′9″, and similar lengths.

Railway Fence Posts

Posts, 6′ × 6½″ × 3¼″ half-round }
„ 6′ × 3½″ × 3½″ square } pointed 9″/10″ at one end.
Rails, 10′6″ × 3″ × 1¼″.
12′0″ × 4″ × 1½″.
12′0″ × 4″ × 2″.
No crooked, undersized, or otherwise defective pieces will be accepted.

THE FINE STRUCTURE OF THE FIBRES OF NORMAL AND TENSION WOOD IN BEECH (*FAGUS SYLVATICA* L.) AS REVEALED BY X-RAYS

By R. D. PRESTON (*Dept. of Botany, University of Leeds*)

AND

V. RANGANATHAN (*Forest Research Institute, Dehra Dun; sometime Govt. of India State Scholar at University of Leeds*)

INTRODUCTION.

In a recent contribution to this journal Chow (1) has presented the results of detailed chemical and microscopical analyses of normal and tension wood in beech. At the request of the Officer-in-charge, Chemistry Section, Forest Products Research Laboratory, Princes Risborough, we have now examined his material in the X-ray spectrometer in the hope that it might thereby prove possible to supplement the work already published. It is the purpose of this paper to present the results of this examination and to discuss some of the implications in terms of the general picture presented by Chow. It is unnecessary here to enter into any discussion of the literature on the structure and properties of tension wood—an account will be found in Chow's paper—but one or two features generally recognized as typical of tension wood, and some of those emphasized by Chow's work, may be reviewed briefly, in so far as they will come under discussion later in this paper. It is accepted that the fibres of tension wood are usually longer than those of normal wood. This is supported by Chow's results, in which, however, the difference is small, though significant. A more striking difference brought out by Chow is that the tension-wood fibres are much narrower than are those of normal wood; and a further point to be borne in mind is that the ratio of fibre volume to vessel volume is greater in the tension wood of beech than in normal wood. Together with these structural differences goes a difference in shrinkage and swelling, particularly marked in the longitudinal direction. Finally, tension-wood fibres isolated by maceration are found to swell much more laterally than do corresponding cells from normal wood.

It seems inevitable that all physical properties of timber will vary, to a greater or less degree, as the organization of the structural component, cellulose, of its cell walls varies; and a correlation of this kind would seem more probable for properties like shrinkage which do not as a rule show any marked variation with density. It seems likely, therefore, that some information might be given by the X-ray diagrams of beech wood. In point of fact, the dimensions alone of the cells give a strong clue as to the difference in organization to be expected, in view of work now in progress in the Botany Department at Leeds, and it may be said immediately that the diagrams do show differences of the type predicted. The interpretation of these diagrams, however, is not so unambiguous as might at

first sight appear, and some care must be used in their interpretation. It will, therefore, be as well first to discuss very briefly the type of information to be drawn from X-ray diagrams of wood.

THE FIBRE DIAGRAM.

The cellulose component of cell walls is now well recognized as consisting of a series of long molecular chains, of which each link is a β-glucose residue (4). In certain localized regions of the wall these chains lie strictly parallel to each other and at regular distances apart, forming therefore a three-dimensional crystal lattice. These regions, the so-called 'micelles', are probably of the order of 50 A.U.[1] wide and at least 500 A.U. long, and are therefore well below the limit of microscopic visibility. In the spaces between the micelles the chains are oriented more or less at random and irregularly spaced. Individual chains are undoubtedly much longer than the micelles, so that any one chain probably runs through many micelles and several intermicellar spaces. It should therefore be clear that the results of X-ray analysis refer only to the crystalline part of the cellulose. The non-crystalline fraction is not recorded in the diagram and nothing can be said concerning its condition. The micelles are found usually to lie more or less parallel to each other and thus have a common direction, or preferred orientation, which is commonly tilted to the long axis in elongated cells. The micelles may thus be regarded as lying along spirals in the wall. It is particularly to be remembered, however, that in fact they never do lie strictly parallel to each other, being distributed possibly on all sides of the preferred orientation in normal distribution, i.e., they possess some angular dispersion.

A structure of this kind will naturally be anisotropic, and, particularly for our present purposes, will show anisotropy of swelling in such a way that the swelling in water in a direction at right angles to the chains will be large (of the order of 20 per cent.), and much smaller in a direction parallel to them (of the order of 1 per cent. or less, depending on the angular dispersion). It is to be noted that this is true even though swelling occurs by water adsorption in the non-crystalline fraction and not inside the crystalline regions. The degree of swelling will clearly depend also on the type and amount of the incrusting substances present in the intermicellar spaces (2, 3, 6) but the anisotropy of swelling will be to a large extent a function of the orientation of the crystalline component in the micelles. Therefore it becomes a matter of some moment to determine the orientation of cellulose chains in both normal and tension wood, and the method employed will be clear from Fig. 8, plate VIII. In the micelles of an isolated fragment of cellulose there occur a number of molecular planes, each of which will 'reflect' a beam of X-rays at an angle of incidence θ given by the Bragg Law

$$\lambda = 2d \sin \theta,$$

where λ is the wave-length of the X-radiation employed and d is the distance between any two successive planes. If the beam is normal to the cellulose chain direction and the chains are imagined lying vertically, then, provided the specimen

[1] A.U. = 1/100,000,000 cm.

is rotated about this vertical line, the beam will be 'reflected' in a horizontal plane by any molecular planes lying parallel to the chain direction, as these come in turn into a position to reflect. There are in cellulose three principal planes of this kind, spaced 6·1, 5·4, and 3·9 A.U. apart. It is clear that in a piece of wood, or even in a single fibre, the individual 'fragments', of which the walls are composed, are in effect rotated about an axis which is parallel to the grain of the wood, or to the length of the single fibre. Therefore, we find that these reflections do occur. If a photographic plate is so placed as to receive such reflections, then the X-ray photograph produced is of the type shown in Fig. 8, plate VIII. In this figure the molecular chains of cellulose in the specimen all run approximately parallel to each other and to the cell length and have been so arranged as to lie parallel to the longer edge of the page. When the chains run in a spiral the derivation of the diagram is a little more difficult. The 'spiral' diagram has long been known and has recently been examined in some detail (8). We may note here that the effect of the spiral is merely to draw out the lateral 'spots' into arcs whose lengths, after a small correction, give the angle of the spiral.

METHODS AND RESULTS.

The early and late wood of samples used by Chow (1) were examined separately, since previous experience in this laboratory had shown that they can give quite different diagrams. Specimens were cut accurately parallel to the grain, and some 2 mm. wide tangentially and some 1 mm. thick radially. Each specimen was arranged in the spectrometer so that the X-ray beam traversed it radially and the diagram was recorded on a flat film. The photographs were all taken on a Shearer tube, with the standard conditions, using CuKα radiation. They are recorded here in Figs. 1 to 4, plate VIII. It is to be noticed that the spread of the lateral arcs is marked in all cases but is greater in normal than in tension wood. This difference is more marked in spring than in summer wood samples, but even in the latter the arcs are much more 'fuzzy' in normal than in tension wood; and in particular the 021 arcs are much more dispersed. The impression is, therefore, that in normal wood the molecular chains of cellulose are more dispersed than they are in tension wood, so that in the latter they tend to lie more nearly parallel to the grain. Measurement of the lateral spread of the equatorial arcs is made somewhat uncertain by the fact that actually each arc can be traced over almost a complete circle; but taking the angle at which the intensity of the arcs falls off most rapidly, the figures given in Table I may be obtained. There is, naturally, some

TABLE I. *Half-angular Spread in the Lateral Arcs of the X-ray Diagrams of Normal and Tension Wood*

	Normal wood	*Tension wood*
Early wood	21·0°	14·0°
Late wood	15·0°	12·0°

subjective error involved in this measurement, so that the precise figures given

are not to be taken too literally. However, they are a clear expression of the type of difference observed above between normal and tension wood.

DISCUSSION.

The diagrams presented obviously need careful scrutiny before definite interpretations can be reached, in view of the complexity of beech wood and of the anatomical differences between normal and tension wood demonstrated by Chow (1). Of the various elements of the wood, however, only two, the fibres and the vessels, are likely materially to affect the X-ray diagram; and since we are here concerned mainly with the fibres, to whose properties the two types of wood as a whole undoubtedly owe most of their peculiarities, it is necessary to assess the likelihood that the vessels have contributed materially to the diagram, and the extent to which such a contribution could interfere with that of the fibres. We remember that in fibres the cellulose chains, as a rule, are wound in very steep spirals, whereas in vessels the spiral is commonly very flat (5). Under the assumption that this is true for beech—and the possibility that it is not true seems very remote—then the diagrams presented in Figs. 5, 6, and 7, plate VIII, will serve to elucidate the point at issue. These are diagrams of spirals made by winding filaments of highly oriented viscose rayon around a single horse-hair as former, in such a way that the finished spiral has a diameter of less than 0·5 mm. and lies therefore entirely in the beam. In Fig. 5 the filaments make a common angle of 0° to the length of the spiral and in Fig. 6 the corresponding angle is 90°. In the former case we find arcs very much like those observed here in the diagrams of wood (except, of course, that the arcs are somewhat differently disposed, since the filaments used are composed of regenerated, and not native, cellulose). In the latter case the arcs occupy the meridians and are much fainter and more drawn out. In Fig. 7 the two diagrams of Figs. 5 and 6 are superposed. A comparison with Fig. 5 will show that in a 'mixed' specimen, in which steep and flat spirals are present in equal effective quantities, the flat spiral diagram does not materially interfere with the steep one. When the high ratio of (fibre wall)/(vessel wall) in beech is taken into account, it would seem reasonably safe to take the equatorial arcs as representative of the fibres only. In that case the differences in dispersion of cellulose chains which the diagrams imply are to be regarded as characteristic of the fibres. It is not easy to say precisely what this means in terms of the organization of the fibres, and a precise statement of structure cannot be made on the basis of these diagrams alone. Ancillary considerations allow us, however, to make some approximation to the truth. None of the diagrams of wood presented here are strictly comparable with the diagram given by model spirals. In the latter, photographs show each of the lateral arcs separated into two spots, one at each end of each arc. In the wood photographs the gradual diminution of intensity in passing from the middle of the arcs suggests at first sight that the chains of cellulose have a preferred orientation parallel to the length of the fibres, but with considerable angular dispersion about this axis. Wide experience of diagrams of wood, however, makes it seem highly probable that the cellulose chains actually lie along a spiral, so that there must be considerable angular dispersion about the

spiral direction; and this is supported by those observations, both on normal and tension wood, which have already been made in the literature. A good deal of this dispersion probably occurs as a variation of the spiral angle, from fibre to fibre in the specimen irradiated. The figures presented in Table I can be taken, therefore, as measuring very roughly the average angle which the spirals make with the long axis of the fibres. The conclusion we may thus reach is, clearly, that the spirals are steeper in tension than in normal wood.

It is easy to see that such a difference in structure may be associated with some of the physical differences between the two types of wood, mentioned by Chow (1). Thus, evidence has accumulated in this laboratory that, in tracheids at least, the steepness of the wall spiral is correlated positively with cell length; so the longer the cell the steeper the spiral. If this could be substantiated for fibres also, then the steep spiral associated with tension wood could be attributed to the slightly greater cell length reported by Chow (1). At the moment the observed difference in cell length seems decidedly on the small side, from this point of view, but judgement is better suspended until the tracheid correlation has been fully analysed. With regard to the difference in swelling and in swelling anisotropy in transverse section, reported by Chow (1), it is not possible without further investigation to say how far this can be explained in terms of differences in organization of the cellulose component of the walls and how far in terms of the different lignin content and distribution. It seems probable that both play a part. With anisotropy in longitudinal section it does seem possible to be a little more definite. It has already been shown (7) that, with individual wood fibres, the steeper the spiral the greater the contraction in length on drying; and this would clearly fit qualitatively[1] with the results presented here, since tension wood shows a markedly greater contraction than does normal wood. Even here, however, some doubt arises, since it is not clear that wood in bulk will behave like isolated cells in this regard; in fact Stillwell (9) reports that in some species steepening of the spiral is associated with smaller contraction longitudinally of pieces of wood. At present we have this point under investigation. It is as yet too early to make any definite statements, but it may perhaps be said now that it does not seem impossible to reconcile this divergent behaviour of wood cells and bulk wood; and it still seems that, with species in which the cellulose chains in the fibres lie approximately longitudinally, the steeper spirals may confer upon the wood a greater ratio of longitudinal to transverse contraction. A different interpretation of the difference in longitudinal contraction is given by Chow (1), based upon his observation that, in tension wood only, the walls as seen in longitudinal view are traversed by fine transverse striations or cracks. Since, however, these markings run over more than one fibre continuously, it seems probable that the markings are in the primary wall; and it seems doubtful whether the delicate primary wall can ever override the secondary wall in control of shrinkage and swelling.

[1] A quantitative relation is not to be expected, since the relations concerned (7) involve a constant y depending on the nature of the material. The relations only hold strictly, therefore, with cells of similar chemical composition.

SUMMARY.

A series of X-ray diagrams is presented of normal wood and tension wood in beech, of specimens identical with those used by Chow in an earlier contribution to this journal. From these diagrams it is shown that the cellulose chains in the walls of fibres in tension wood are oriented more nearly parallel to the length of the fibres, and therefore the grain, than they are in the corresponding normal wood. It is suggested that a number of the differences in properties between normal and tension wood in this species, and in particular the difference in longitudinal shrinkage, are in some part due to this difference in molecular structure.

ACKNOWLEDGEMENT.

Our thanks are due to the Government of India for the award of a State scholarship to one of us, V. Ranganathan.

LITERATURE REFERENCES.

(1) Chow, K. Y.: 'A Comparative Study of the Structure and Chemical Composition of Tension Wood and Normal Wood in Beech (*Fagus Sylvatica* L.).' *Forestry*, xx. 62–77, 1947.
(2) Kundu, B. C., and Preston, R. D.: 'The Fine Structure of Phloem Fibres, I. Untreated and Swollen Hemp.' *Proc. Roy. Soc.* B, cxxviii. 214, 1940.
(3) Majumdar, G. P., and Preston, R. D.: 'The Fine Structure of Collenchyma cells in *Heracleum sphondyllium*, L.' *Proc. Roy. Soc.* B, cxxx. 201, 1941.
(4) Preston, R. D.: 'The Molecular Chain Structure of Cellulose and its Botanical Significance.' *Biol. Revs.* xiv. 281, 1939.
(5) —— 'Wall Structure and Growth, I. Spring Vessels in some Ring Porous Dicotyledons.' *Ann. Bot. Lond.*, N.S. iii. 507, 1939.
(6) —— 'The Fine Structure of Phloem Fibres, II. Untreated and Swollen Jute.' *Proc. Roy. Soc.* B, cxxx. 103, 1941.
(7) —— 'Anisotropic Contraction of Wood and of its Constituent Cells.' *Forestry*, xvi. 32, 1942.
(8) —— 'The Fine Structure of the Wall of the Conifer Tracheid, I. The X-ray Diagram of Conifer Wood.' *Proc. Roy. Soc.* B, cxxxiii. 327, 1946.
(9) Stillwell, C. W.: *Crystal Chemistry*, McGraw Hill, 1938.

DESCRIPTION OF PLATE.

In all these X-ray diagrams the specimen is to be imagined as lying in the plane of the paper and with its length, or grain, lying parallel to the longer edge of the page.

Fig. 1. Early part of annual ring in normal wood of beech. This photograph is more strongly printed than the rest, in order to show the general appearance of the diagram of wood. The rest of the photographs are printed less strongly, in order to give a more reliable estimate of the spread of the strong lateral arcs. The figures in Table I are derived from the photographs presented here, except that in the case of the specimen represented by fig. 1 a photograph was used of intensity comparable to the rest of the set.

Fig. 2. Early part of annual ring in tension wood of beech. Note the sharpness of the arcs in comparison to those of fig. 1.

Fig. 3. Late part of annual ring in normal wood.

Fig. 4. Late part of annual ring in tension wood. Note the sharpness of the arcs in comparison with those of fig. 3.

Fig. 5. Parallel bundle of filaments of well-oriented artificial silk (i.e. spiral of zero angle).

Fig. 6. Filaments of artificial silk (identical with that used for fig. 5) wound in a flat spiral (i.e. spiral of 90° angle). Note that the arcs are now drawn out into complete circles, most intense along a vertical line. The length of the spiral is parallel to the longer edge of the page.

Fig. 7. (Figs. 5 and 6 superposed.) Note the resemblance of this photograph to those of wood presented above.

Fig. 8. Diagram illustrating the production of an X-ray photograph. The X-ray beam is collimated through a fine hole in a lead cylinder, *S*, forming the so-called slit. The beam then passes through the fibre bundle, or wood specimen, *F*, in a direction at right angles to the fibre length, or grain. The point on the photographic plate where the main beam would strike it is protected by a small lead cup which casts the circular white shadow on the centre of the photograph. The spots on the photograph each correspond to specific molecular planes in the specimen.

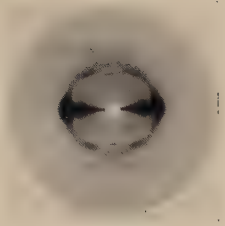


FIG. 1

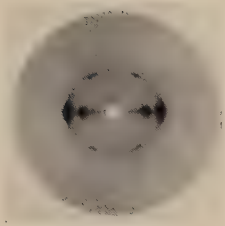


FIG. 2

FIG. 3

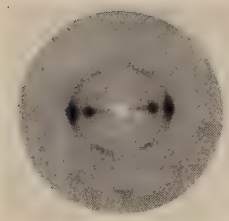


FIG. 4

FIG. 5

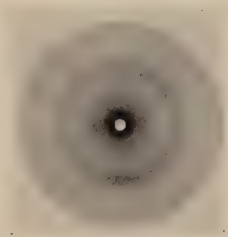


FIG. 6

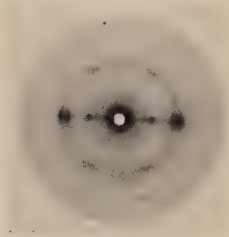


FIG. 7

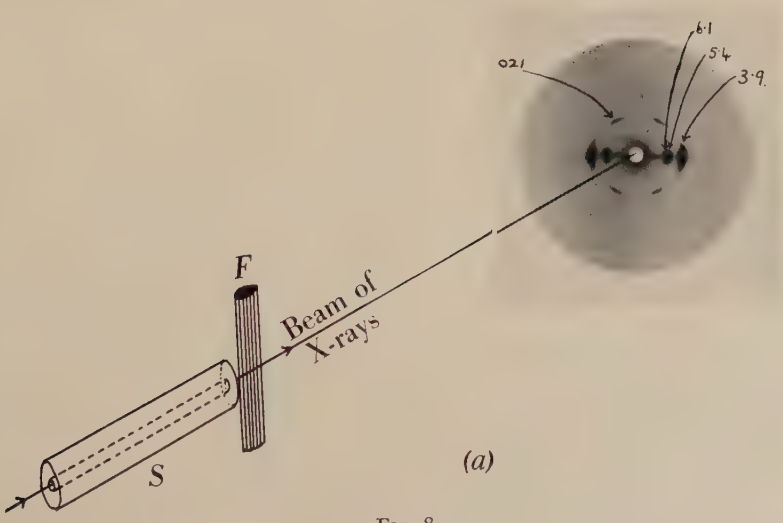


FIG. 8

PLATE VIII

BATS

By J. M. D. MACKENZIE

SUPERFICIALLY bats are rather unprepossessing animals, so it is perhaps not astonishing that very few men have studied them in the way that birds have been studied. Although their crepuscular and nocturnal habits make them difficult, and their reputation for being smelly and verminous unpleasant to work with, they are very interesting indeed. According to Galambos and Griffin (4) they avoid obstacles and locate their prey by the reflection of supersonic waves, that is, the echoes of their squeaks, or audio-location, a very close relative of radio-location. Their breeding-habits are almost unique, and they are more skilful flyers than birds. They manage prey which is too large to deal with by the jaws alone by stuffing it into a pouch formed by the inter-femoral membrane, or in the case of the horseshoe bats, the inter-brachial membrane, thus leaving the fore-limbs free for flying.

G. M. Allen (1) surveys the bats of the world and gives a remarkable series of facts. Fossil bats 50 to 60 million years old, that is, of early Eocene age, show few differences from the most primitive bats of to-day. But other families have developed in special directions, such as the vampires with their teeth adapted to take a shaving off the skin; the fish-eaters, *Noctilio* and *Pyzonyx*, with greatly enlarged hind feet for seizing their food; the *Glossophaginae* with tongues extending an inch from their lips to enable them to suck juices and nectar, which pollinate certain flowers (*Bombax*, *Durio*, *Ceiba*, *Agave*); *Tylonycteris* with sucker-pads on their feet to help to cling to the smooth bamboos in which they live; and the fruit bats, which are vegetarians. Bats are really tropical animals, and it is in the tropics that they have developed most freely and are most numerous. In the temperate zones, including North America and Great Britain, the insect life on which bats depend disappears in winter, so the bats must either hibernate or migrate. There is evidence that they do both. In America certain bats living in trees definitely move south in the winter and north in the spring; while in Great Britain the variation in numbers of bats in caves means that they move elsewhere in summer. When hibernating, their temperature drops to that of the surrounding air, which decreases metabolism and enables them to stand long fasts. (The winter temperature in caves is higher than the temperature outside, usually varying between 40 and 50 degrees Fahrenheit.) Even in summer the temperature of a sleeping bat drops to that of the air, which means a great saving in energy.

As to numbers, an estimate of the bats in the Carlsbad caverns in New Mexico is 9 million. In emerging they form a cylindrical column 20 feet in diameter, and emergence continues for 20 minutes. A similar number has been reported from caves in southern Asia, I think on the Salween river, and in the tropics the total of fruit bats in big roosts runs into enormous figures. I have watched flying-foxes

(fruit bats) crossing the Chindwin river at Kindat, Burma, in a continuous stream for an hour on end at dusk, and they were still to be heard after it was too dark to see them. In Great Britain the numbers are not so great, but the insect population is also lower and even the smaller numbers of bats take a heavy toll.

Species which live in trees often have brightly coloured patches which break up their outline. Bats also live in caves and houses, amongst palm fronds, in weaver-birds' and sunbirds' nests (*Kervoula*), in hollow joints of bamboos, and under stones on the sea-shore. In fact they may be found in almost any hole or cranny, but each species prefers a particular type of roost. Some congregate in enormous numbers, some live alone, even if the available space is big. In New Zealand, *Mystacops*, the short-tailed bat, is dying out because all hollow trees are being felled. This has significance in Great Britain where also we fell our hollow trees.

Bats seem to have some kind of homing instinct. In America specimens of the local species have been carried up to 30 miles and have returned to their original roost, often in a very short time, an hour or so. This affects the idea of taking them where they are wanted and releasing them there, for it does not seem certain that they will stay. There is some evidence that there is a territorial instinct, for if a bat on a recognized beat is shot it is not replaced for some time. Bats have been ringed in Germany and found up to 460 miles away, so they are not static.

They have few enemies. Owls kill a few, hawks occasionally kill them at dusk, and a few reptiles eat them. Large trout, driver ants, and big spiders' webs are also amongst the causes of death. Certain birds habitually prey upon bats, haunting the caves as the bats come out at dusk. Examples are, in America, *Falco albigularis*, and in Asia and Africa, *Machaerhamphus alcinus* and *anderssoni*.

While the majority of bats feed on insects, there are several adaptations. Besides those which eat fish, or nectar and pollen, referred to above, the true vampires, *Desmodus*, *Diphylla*, and *Diaemus*, suck the blood of birds and mammals, and in doing so may transmit a form of rabies in eastern South America, and a disease of horses and cattle, called murrina in Panama. They may also disturb livestock to such an extent that it has to be moved. I have seen small birds, fish, a mouse, and a frog, or their remains on a bungalow floor in Burma, brought in by false vampires, *Lyroderma*; and gecko lizards, small birds, and bats are also recorded as eaten. Some bats have been proved to catch their prey on the ground, indeed some insects and spiders which are eaten by bats cannot fly at all. This links with reports that certain bats in Britain catch larvae off the leaves of trees.

Although bats act as hosts for a considerable number of parasites, these are mostly peculiar to themselves. It is satisfactory to know that there is no recorded case of the transmission of flukes, tapeworms, threadworms, &c., from bats to man.

Breeding-habits, where they have been observed, are peculiar. The females are covered in autumn, the semen lying dormant throughout the winter and only becoming active again in spring, on ovulation. There seems to be some doubt as to whether some individuals, especially young ones, are not covered in the spring. For a short time the female carries her young with her when she goes hunting,

the young clinging to her chest by the fur; but it soon becomes too heavy and is left behind.

What makes bats of commercial importance is their appetites, which are enormous, and the fact that they feed largely on beetles and moths with procryptic coloration, that is, camouflaging coloration with the object of protection. Such insects rest in the daytime, and it is doubtful if any great number of them are found by birds: at night they are flying about or at least are active and easily disturbed, and bats make full use of their opportunities. Procryptic coloration is of no use against the reflection of supersonic waves. Professor E. B. Poulton (9) has summarized our knowledge of bats' food. The long-eared bat has a habit of taking its larger captures to certain spots to devour, and the result is that moth wings, which are not eaten, can be found on the ground under these 'dining-rooms'. Remains of 1,328 moths were collected and identified from a number of places all over Great Britain and have contributed largely to our knowledge. Poulton's considered opinion is given in the last paragraph of his conclusions, and is worth quoting: 'The observations condensed above, and the list of discarded wings appear to prove that bats are of great economic value to man. Their attacks on *Lepidoptera* and *Diptera*, carried on when the prey is active or easily disturbed, must produce a considerable effect, especially when the quickly renewed voracity is taken into account.' I would add *Coleoptera*, as my own attention was called to bats when a wing-case of a cockchafer was dropped close beside me.

Millais (8) and Barrett-Hamilton (2) both give excellent descriptions of the habits of bats for those who want more information. Most bats have two flight and feeding periods each night, one after sunset and the other before dawn, and in those periods of violent and intensive activity they catch an enormous number of insects, said to be from one-quarter to one-third of their own weight on each occasion. One observer reports them as returning to rest 'distended like cricket balls'. Others give formidable lists of foods eaten in captivity, and Poulton quotes Moffat as saying of noctules and their allies 'the truly monstrous rate at which bats of this group consume their prey'; Barrett-Hamilton (2) says a noctule will eat 30 cockchafers in half an hour while in captivity, and figures such as 1,500 house flies and 1,000 mealworms in a night speak loudly for themselves. There is no doubt that their appetites resemble those of birds rather than mammals. It may be noted that shrews and moles, which are also insectivores, demand enormous quantities of food if they are not to die of starvation. An animal which eats from half to two-thirds of its own weight every night throughout the summer is of considerable importance as an insect control, even if its weight may not be very great.

A list of bats recorded from Great Britain will be found in the Appendix.

The greater horseshoe, the serotine, and the noctule are all large, with strong teeth, and are eminently suited for dealing with large and hard beetles and large moths; the whiskered and Daubenton's and the pipistrelle are small, with weak teeeth, suited for much smaller and softer insects, such as Tineid moths and gnats. In captivity bats definitely refuse insects which are notoriously distasteful, such as *Meloë*, the oil beetles, and *Abraxus grossulariata*. Some they will eat

under protest if they are very hungry, others they will not touch at all. Certain bats, cave-haunting species, have been recorded as eating woodlice, spiders, and flightless insects which cannot have been caught on the wing, and Barrett-Hamilton quotes Caton Haigh as believing that long-eared bats take small caterpillars from the leaves. There is nothing inherently unlikely in this, as fruit-eating bats take all their food from rest. Poulton quotes Oldham as saying that a barbastelle picked flies off the ceiling of a room, and says that Leisler's bat eats dead honey bees, but exhibits signs of terror on being offered a live one, which may be connected with finding live bees in the holes in trees in which it roosts.

Poulton's 1,328 identifications (9) from the 'dining-rooms' of long-eared bats will only cover the larger insects, as anything easily manageable is devoured on the wing. The numbers of each species are given in the appendix, and some are significant; e.g. large yellow underwing, 361, dark arches, 282, and common rustic, 108, or about 27, 21, and 8 per cent. of the total. The food of other bats is much more difficult to determine as the prey is so thoroughly triturated that the stomach contents are not identifiable. Records are given in the Appendix. A selection of species recorded as eaten, mostly in captivity, is given to show that the diet may be very varied, from *Melolontha*, *Geotrupes*, and *Smerinthus* to caddis flies. Of the natural foods, most species have procryptic coloration and are harmful to woods or crops or both. Details will be found in Poulton's paper.

The record of *Smerinthus populi* L., the Poplar Hawk Moth, quoted by Poulton is interesting as the investigation of wings found in Great Britain was started by a small collection of wings from the floor of a rest-house in Uganda, dropped by unknown bats, and sent by Dr. G. D. H. Carpenter, Hope Professor of Entomology, University of Oxford; of 7 species identified, 6 were Sphingids and 1 a Noctuid.

Jollyet (6) makes a strong demand for encouragement of bats in French forests, but does not seem to produce any definite proof that bats are beneficial. He gives instructions for making roosts, but it is not known if they were ever tried. Bat roosts were tried in America as a mosquito control, but it was found that bats did not eat many mosquitoes, and the experiment was abandoned.

C. C. Brooks says (3) that long-eared and short-eared bats were found to have *Evetria buoliana*, the pine-shoot moth, in their stomachs. The short-eared bat is unidentifiable (Brooks was killed in an accident before he could amplify his notes), but the main point is that there are at least two species which eat this pest.

Several species, such as the whiskered bat, feed right in amongst the branches and leaves of trees, from which they appear to drive the insects before seizing them, often after they have flown a very short distance, inches only. (This point recurs below, in observations quoted from Vesey-Fitzgerald.)

The distribution of bats is very imperfectly understood. All the British bats, except the barbastelle and Bechstein's, about which little is known, are common somewhere, and the probabilities are that they are common but unidentified in other places also. Scotland is not well off for species: apart from doubtful or single records, the whiskered, Natterer's, Daubenton's, and the long-eared bats, the pipistrelle, and the noctule are recorded, but only the last four are common.

The noctule, the long-eared bat, the whiskered bat, and Leisler's bat (which occurs most commonly in Ireland) are species which like woods and trees particularly, and Daubenton's bat is confined mainly to rivers and lochs.

Mr. B. Vesey-Fitzgerald, the writer on animals and one of the leading authorities in Great Britain on bat ecology, has kept almost all known British species in captivity, and by providing roosts has been able to increase the numbers round his house. The roosts are boxes, with laths for suspension, about a foot cube, and are hung in trees. The best way to help colonization of these roosts is to capture a female and confine her for a week or two in the box; or alternatively to smear the inside with droppings from an established roost. He thinks that it should be possible to increase the numbers of bats in forests by these means.

Mr. Vesey-Fitzgerald has kindly sent me the following remarks in a letter:—

'The long-eared and whiskered habitually take their prey at rest. That is, they pick it from the leaves and branches of trees, hedges, and so on, and also from fences and walls. The whiskered is especially fond of spiders. Both will take prey in flight but would rather take it at rest. Natterer's also takes prey at rest but the technique is somewhat different, since this species has a habit of disturbing the foliage by flying into it or just touching it and so dislodging the insect population. Both horseshoes take prey from the ground as well as in flight. In captivity, this is also the case with the whiskered and long-eared, but I have not seen them do it in the wild. None of the other British species, so far as I am aware, do this. Certainly none of them do in captivity.

'All the British species eat beetles. The only one that I know, however, that habitually takes chafers is the noctule. I have no doubt that the serotine would do so if a chafer happened by, but they do not hunt them habitually as does the noctule.

'The pipistrelle and Daubenton's both take gnats and mosquitoes, but most of the others will refuse them unless they are very hungry. My pipistrelles, however, have a distinct liking for them.

'No bat I have ever had has ever taken a Magpie moth or a garden tiger, and I have never found traces of either species under roosts.'

It has been pointed out (7) that, in felling hollow trees and substituting plantations, the forester is depriving bats of roosting-places as well as birds of nest sites. Hiesemann (5) says that bats are sometimes found in nest-boxes at Seebach, adding that they should not be disturbed, as they are as useful as birds. I have found them in nesting-boxes myself. It is suggested that boxes hung up in woods as roosts should be tried. Although bats will go a considerable distance for food, and seem to have an uncanny knowledge of where it is likely to be found, some species appear to change their roosts from time to time, probably for convenience in hunting; and it may be of advantage if we can find a substitute for the hollow trees which we have removed. Bats undoubtedly are a very welcome complement to birds as insect controls, and we cannot afford to go on neglecting them.

A point, perhaps important, is that most parasites such as Ichneumons and Chalcids are diurnal. As bats are nocturnal, or at least crepuscular, it follows that they will not kill many of these useful insects, a crime which has been held against certain birds, e.g. swallows eating ladybirds. Although it is generally

thought that the good which birds do in killing harmful insects far exceeds any possible damage from the destruction of beneficial ones, there is no doubt that the balance would be even more favourable if fewer parasites were killed.

SUMMARY.

A general outline of some of the main facts about bats is given. They are voracious, eating as much as a half to two-thirds of their own weight of insects in a night. Their nocturnal food includes large numbers of protectively coloured insects which rest by day and so tend to escape diurnal birds. Some bats live in woods and may be important as insect controls. A list of British bats is given, and data by Poulton and others on the insects commonly eaten by bats. The provision of roosting-boxes in woods is suggested, to encourage bats and to take the place of the hollows in trees removed in silvicultural fellings.

ACKNOWLEDGEMENTS.

I am indebted to Mr. Brian Vesey-Fitzgerald for permission to use the information he has given me, which makes a valuable addition to available facts, and to Captain N. D. Riley of the Department of Entomology at the British Museum (Natural History) for bringing the names of moths up to date and help in identifying some uncertain records.

LITERATURE REFERENCES.

(1) Allen, G. M.: *Bats*. Harvard Univ. Press, 1939.
(2) Barrett-Hamilton, G. E. H.: *A History of British Mammals*, vol. 1, Gurney and Jackson, 1910.
(3) Brooks, C. C.: *Studies on the Pine Shoot Borer* (*Evetria buoliana*, Schiff), For. Com. Bull. No. 16, 1936.
(4) Galambos, R., and Griffen, D. R.: 'Obstacle Avoidance by Flying Bats; The Cries of Bats'. *J. Exp. Zool. Philadelphia*, lxxxix. 1942, pp. 475–96.
(5) Hiesemann, M.: *How to attract and protect Wild Birds*. H. F. and G. Witherby, 1911.
(6) Jollyet, A.: 'Cabanes à Chauve Souris'. *Revue des Eaux et Forêts*, lvi. 1918, pp. 121–6.
(7) Mackenzie, J. M. D.: 'Forest Ornithology (Some Meditations)'. *Scottish Forestry Journal*, lix. 1945, pp. 55–69.
(8) Millais, J. G.: *The Mammals of Great Britain and Ireland*, Longmans & Co., 1904.
(9) Poulton, E. B.: 'British Insectivorous Bats and their Prey.' *Pro. Zool. Soc. London*, ii. 1929, pp. 276–303.

APPENDIX

INSECTS RECORDED AS EATEN BY BATS

Nomenclature in accordance with South's *British Moths* (1939 edition).

For references and abbreviations, see below. Numbers in brackets after 1 P are numbers recorded as taken by Poulton, out of a total of 1,328.

NOTODONTIDAE

Phalera bucephala L. Buff Tip. (*Pygaera*, 1 P (2).)

LASIOCAMPIDAE

Philudoria potatoria L. Drinker Moth. (*Odonestis*, 1 P.)

ARCTIIDAE

Spilosoma lutea Hufnagel. Buff Ermine. (*S. lubricipeda*, 1 P (8).)
„ *lubricipeda* L. White Ermine. (*S. menthrastri*, 1 P (2).)

NOCTUIDAE

Apatele psi. L. Grey Dagger. (*Acronycta*, 1 P (1).)
„ *rumicis* L. Knot Grass. (*Acronycta*, 1 P (1).)
Peridroma porphyrea Schiffermueller. Pearly Underwing. (*Agrotis saucia*, 10 P.)
Agrotis segetum Schiffermueller. Turnip Moth. 1 P (14).
„ *clavis* Hufnagel. Heart and Club. (*A. corticea*, 1 P (1).)
„ *exclamationis* L. Heart and Dart. 1 P (9).
„ *ipsilon* Hufnagel. Dark Sword Grass. (*A. suffusa*, 1 P (4).)
Euxoa nigricans L. Garden Dart. (*Agrotis*, 1 P (5).)
Graphiphora augur Fabricius. Double Dart. (*Noctua*, 1 P (7).)
Amathes C-nigrum L. Setaceous Hebrew Character. (*Noctua*, 1 P (2).)
„ *triangulum* Hufnagel. Double Square Spot. (*Noctua*, 1 P (1).)
„ *xanthographa* Schiffermueller. Square Spot Rustic. (*Noctua*, 1 P (8).)
Diarsia festiva Schiffermueller. Ingrailed Clay. (*Noctua*, 1 P (1).)
Triphaena orbona Hufnagel. Lesser Yellow Underwing. 1 P (91).
„ *pronuba* L. Large Yellow Underwing. 1 P (361).
„ *janthina* Schiffermueller. Lesser Broad-bordered Yellow Underwing. (*T. ianthina*, 1 P (50).) 4 P, 6 P, 10 P.
Lampra fimbriata Schreber. Broad-bordered Yellow Underwing. (*Triphaena fimbria*, 1 P (2).) 10 P.
Mamestra brassicae L. Cabbage Moth. 1 P (63). 4 P, 6 P.
Melanchra persicariae L. Dot. (*Mamestra*, 1 P (1).)
Diataraxia oleracea L. Bright Line Brown Eye. (*Hadena*, 1 P (8).)
Apamea furva Schiffermueller. The Confused. (*Mamestra*, 1 P (1).)
„ *sordens* Haworth. Rustic Shoulder Knot. (*A. basilinea*, 1 P (28).) 4 P.
„ *secalis* L. Common Rustic. (*A. oculea*, 1 P (108).)
„ *obscura* Haworth. Dusky Brocade. (*A. gemina*, 1 P (24).)
„ *crenata* Hufnagel. Clouded Bordered Brindle. (*Xylophasia rurea*, 1 P (21).)
„ *lithoxylea* Schiffermueller. Light Arches. (*Xylophasia*, 1 P (4).)
„ *monoglypha* Hufnagel. Dark Arches. (*Xylophasia polyodon.* 1 P (282).) 6 P, 7 P.
Antitype chi L. The Grey Chi. (*Polia*, 1 P (1).) 4 P.
Euplexia lucipara L. Small Angle Shades. 1 P (4).
Phlogophora meticulosa L. Angle Shades. 1 P (11).
Mornis maura L. Old Lady. (*Mania*, 1 P (5).)
Caradrina clavipalpis Scopoli. Pale Mottled Willow. (*C. cubicularis*, 1 P (40).) 8 P.
Amphipyra pyramidea L. Copper Underwing. 1 P (2).
„ *tragopogonis* Clerck. Mouse. 1 P (83).
Cerastis rubricosa Schiffermueller. Red Chestnut. (*Taeniocampa*, 1 P.)
Orthoria gothica L. Hebrew Character. (*Taeniocampa*, 1 P.)
„ *cruda* Schiffermueller. Small Quaker. (*Taeniocampa*, 1 P.)
„ *stabilis* Schiffermueller. Common Quaker. (*Taeniocampa*, 1 P.)
„ *incerta* Hufnagel. Clouded Drab. (*Taeniocampa instabilis*, 1 P.)
„ *munda* Schiffermueller. Twin-Spot Quaker. (*Taeniocampa*, 1 P.)
Agrochola circellaris Hufnagel. Brick. (*Xanthia ferruginea*, 1 P (7).)
Conistra vaccinii L. The Chestnut. (*Cerastis*, 1 P.)
Eupsilia transversa Hufnagel. The Satellite. (*Scopolosoma satellita*, 1 P.)
Xylena exsoleta L. Sword Grass. (*Calocampa*, 1 P.)
Scoliopteryx libatrix L. Herald. (*Gonoptera*, 1 P (3).) 7 P., 10 P., 11 H.
Plusia chrysitis L. Burnished Brass. 1 P (1).

NOCTUIDAE (*Cont.*)

Plusia gamma L. Silver Y. 1 P (31).
Abrostola triplasia L. Dark Spectacle. (*Habrostola*, 1 P (1).)
Catocala nupta L. Red Underwing. 1 P (2).
Hypena proboscidalis L. Snout. 1 P (1).
Procus strigilis Clerck. Marbled Minor. (*M. miana*, 4 P.)

GEOMETRIDAE

Triphosia dubitata L. The Tissue. (*Scotosia*, 1 P.) 10 P.
Xanthorhoe fluctuata L. Garden Carpet. (*Melanippe*, 1 P (12).)
Ourapteryx sambucaria L. Swallow-tailed Moth. (*Uropteryx*. 1 P (1).) 6 P.
Opisthograptis luteolata L. Brimstone Moth. (*Rumia crataegata*. 1 P (1).)
Biston betularia L. Peppered Moth. (*Amphidasis*, 1 P (1).) 7 P, 10 P, 11 H.
Cleora rhomboidaria Schiffermueller. Willow Beauty. (*Boarmia*, 1 P (7).)
„ *repandata* L. Mottled Beauty. (*Boarmia*, 1 P (2).)

HEPIALIDAE

Hepialus humuli L. Ghost Swift. (Males) 1 P (4), 7 P.
„ *sylvina* L. Orange Swift. (*H. sylvanus*, 4 P.)

HYPONOMEUTIDAE

Hyponomeuta cognatella Hübner. 1 P.

TORTRICIDAE

Evetria buoliana Schiff. Pine Shoot Moth. 1 B, ?B.

The following is a selection of species recorded as eaten in captivity, or under circumstances in which the evidence is less satisfactory than that for the species above. General lists of food include moths, flies, earwigs, beetles, caterpillars and pupae, ants, cockroaches, mayflies, gnats, and spiders.

LEPIDOPTERA

Sphingidae. Smerinthus populi L. The Poplar Hawk Moth. 2 P.
Larentidae. Lygris populata L. Northern Spinach Moth. 4 P, 6 P.
Liparidae. Euproctis sp. Browntail or Goldtail. 5 H.

COLEOPTERA.

Scarabaeidae

Melolontha melolontha F. The Cockchafer. 2 P, 5 H, 10 P.
„ *hippocastani* L. Fern Chafer. 10 M.
Amphimallus solstitialis L. 2 P.
Geotrupes stercorarius L. Dung Beetle. 2 P, 10 P.
Geotrupes spiniger. Marsh. 10 P.

Carabidae

Pterostichus sp. Ground beetle. 10 P.
Nebria brevicollis F. Ground beetle. 10 P.

Staphylinidae

Quedius sp. 10 P.

DIPTERA

Calliphora erythrocephala. Blue-bottle. 1 P.
Scatophaga sp. Dung-fly. 3 P.
Tipula oleracea. Crane Fly. 3 P, 4 P.

NEUROPTERA

Caddis flies. 6 P.

ARACHNIDAE

Meta menardi F. Cave Spider. 10 P.

References and Abbreviations

The numbers refer to the species of bat recorded as eating the animals concerned; the letters refer to the authority quoted. If more than one authority gives the same data, apparently from the same source, one only is listed.

1. *Plecotus auritus* L. Long-eared bat.
2. *Nyctalus noctula* Schreber. Noctule.
3. *Nyctalus leisleri* Kuhl. Leisler's or Hairy-armed bat.
4. *Pipistrellus pipistrellus* Schreber. Pipistrelle.
5. *Vespertilio serotinus* Schreber. Serotine.
6. *Myotis daubentonii* Kuhl. Daubenton's or Water bat.
7. *Myotis mystacinus* Kuhl. Whiskered bat.
8. *Myotis nattereri* Kuhl. Natterer's bat.
9. *Barbastella barbastellus* Schreber. Barbastelle.
10. *Rhinolophus ferrum-equinum* Schreber. Greater Horseshoe bat.
11. *Rhinolophus hipposideros* Bechstein. Lesser Horseshoe bat.

Authorities

B. Brooks (3).
H. Barrett-Hamilton (2).
M. Millais (7).
P. Poulton (8).

SOCIETY'S AND OTHER NEWS

EXCURSION AND ANNUAL GENERAL MEETING

Preliminary arrangements have been made to hold the excursion this year in Morayshire, with headquarters in Lossiemouth, from 23rd to 26th September.

The Annual General Meeting will probably be held at Lossiemouth on the evening of Wednesday 24th. In addition to the usual routine business this meeting will be asked to confirm the alteration of Article XI of the Constitution passed at the last Annual General Meeting, the effect of which will be to increase the number of Councillors from six to ten. It will also receive the Report of the Special Committee appointed to review the Constitution and Rules. The draft of the new Constitution and Rules recommended in the Report will be submitted under Article XVI of the existing Constitution. If adopted at the meeting the new Constitution and Rules will not become operative until confirmed by another General Meeting.

NOMINATIONS FOR OFFICE-BEARERS AND COUNCILLORS

Under existing Rule 4 nominations for Office-bearers and Councillors for 1948 have to be in the Secretary's hands by 31st October next. There is no nomination form, the only requirements being that the nomination must be in writing signed by two Professional Members (i.e. Fellows or Associates) and should clearly identify the nominee.

Nominations are required for:

Office-bearers (for 1 year): President, Vice-President, Editor, Business Editor (each of whom must be a Fellow resident in Great Britain); Secretary and Treasurer (who must be a member); and Auditor.

Councillors (for 2 years): 5 or 3 according as the alteration of Article XI has or has not been confirmed at the Annual General Meeting in September. (They must be Professional Members.)

A list of those now in office will be found at the beginning of this number. All retiring Office-bearers and Councillors are eligible for re-election.

SOCIETY'S MEDAL

The first medal to be awarded by the Society was presented to Sir Roy Robinson, O.B.E. (now Lord Robinson), Chairman of the Forestry Commissioners and Director-General of Forestry, at a dinner in his honour held at the Café Royal, Regent Street, London, on Thursday, 20th March 1947. The President of the Society, Mr. W. H. Guillebaud, Director of Research and Education, Forestry Commission, presided over a gathering of about twenty-five members, including Messrs. Sanger, Long, and Gosling, the three Directors of Forestry, of England, Wales, and Scotland, Mr. M. V. Laurie, Chief Research Officer, Forestry Commission, Mr. Ray Bourne, Mr. R. C. Mould, Sir Harold Glover, and Mr. M. Philips Price, M.P. Many other members indicated that they would have liked to be present but were prevented by the difficulties of travelling and of finding hotel accommodation in London.

Mr. Guillebaud presented the medal after a speech outlining the leading part taken by Sir Roy in British forestry since the formation of the Forestry Commission in 1919. Sir Harold Glover, Indian Forest Service (retired), who was a fellow student at Oxford under Sir William Schlich when Sir Roy Robinson was training there, also spoke.

In acknowledging the honour done to him by the Society Sir Roy spoke of his very keen appreciation and delivered an address which forms the first article of the present number of *Forestry*. It recalls the article by the same author, using the same title, 'British Forestry', which was the first article of the first number of *Forestry* (volume i, number 1, 1927). The formidable difficulties overcome in the past are cited as a good omen for success in any future problems.

HONOURS

The King's Birthday Honours List of June 1947 included the conferment of a barony on Sir Roy L. Robinson, O.B.E., Chairman of the Forestry Commission of Great Britain. This signal honour to the profession, the Commission, and Sir Roy himself is unique. It marks the climax of a great career, and the recognition of the vital importance of forestry and the forester in the national life and economy.

THE LATE MR. W. ANGUS MUIR, M.C., M.A.

Angus Muir died at Cardiff on the 2nd April 1947, at the age of 53 years. Many members of this Society and others have lost a cherished friend. He was a lovable and modest man, and he served forestry with a single-minded devotion.

Many professions have been enriched by sons from Scottish manses. We have a few in forestry, and Muir's father, the Rev. William Muir, was a distinguished Scottish Churchman.

Angus Muir served in the Royal Scots Fusiliers throughout the whole of the First World War, and was decorated with the M.C. He was a graduate of Glasgow University, and obtained his Diploma in Forestry at Cambridge. He was appointed to the Indian Forest Service in 1921 and continued in India until 1929. He became District Officer in the Forestry Commission (Great Britain) in the following year and was acting as Conservator in South Wales at the time of his death. Most of his service with the Forestry Commission was in East Anglia and in the south-east of England. Because people liked him personally, he made friends for forestry amongst the critical, and this was especially valuable in East Anglia. At the outbreak of war he was transferred to Timber Production, and was Divisional Officer in the Ministry of Supply, Timber Production Department, in Kent, Surrey, and Sussex. This post gave scope for his administrative gifts, and he made many new friends in the timber world. He was one of the members of the party that went to Germany in 1945 to investigate the possibilities of getting timber there, but he was unable for reasons of health to join the organization set up later for this purpose.

His only son, F./O. Kenneth W. A. Muir, R.A.F., was killed in May 1944, while commanding a Lancaster bomber. The sympathy of members of the Society will go out to Mrs. Muir and his daughter Sybil, who served with the U.S. Army Air Force and as a F.A.N.Y. in Italy.

H. M. S.

REVIEWS

Longleaf Pine. By W. G. Wahlenberg. Charles Lathrop Pack Forestry Foundation, 1214 Sixteenth St., N.W., Washington, D.C., in co-operation with the Forest Service, U.S. Department of Agriculture. Price $5.

Review by W. M. McNeill

IN his Foreword to this book Dean Graves writes: '*Longleaf Pine*, by W. G. Wahlenberg, is a contribution of exceptional significance to the literature of American forestry. It is a comprehensive monograph, bringing together and interpreting such pertinent information as exists regarding one of the most important species of trees in the United States.'

Such a testimonial should at least demand our attention, but here is more than a very complete encyclopaedic compilation. To read this book is to read about a tree as one would read about a race of mankind, and a race which has played no small part in making history. It is essentially the story of man's intemperate greed and irresponsible destruction, followed by the desire to piece together the fragments of the thing he has broken.

The value of a monograph such as this lies not only in the wealth of accessible information but also in the ideas this information promotes. The facts are presented in five main parts, namely, Resources, Uses, and Properties of Longleaf Pine; Ecology; Regeneration; Protection; Management. Each part is divided into chapters and these, in turn, into sections, which makes the Table of Contents a quick means of finding any particular item of information. Each chapter starts with a lucid introductory statement and ends with a well-balanced summary of the facts.

Naturally, in such a comprehensive study, different items will arouse varied interests, but certain facts stand out like dominating features in the landscape and cannot fail to arrest attention. So we read that, when the first colonists arrived, there were between 30 and 60 million acres covered with practically pure longleaf pine, stretching almost unbroken from South Carolina to Texas. The fabulous wealth of this great pine belt can be imagined when we remember that longleaf provided the finest pitch-pine timber, not to mention one of the principal sources of turpentine and rosin; 'longleaf timbers exported to England in the 19th century brought prices 25 per cent. higher than any other American pine' (p. 40). The incredible devastation of this possession, almost entirely since 1900, has left only a few scattered remnants of the original forest, while the whole area has shrunk to one-half its size, now composed of second-growth stands. The immense efforts at protecting and preserving what is left supply most of the voluminous information collected in this book.

The ecological studies and investigations are the most interesting and instructive for British foresters. The longleaf pine community is now regarded not as a climax but as a fire sub-climax. Of all the factors controlling the natural distribution of this species, fire is the most important, chiefly through its effects on competing forest species. Exceptional fire resistance and extreme intolerance of shade are outstanding characteristics of longleaf pine. It is fascinating to speculate how the fires necessary for the perpetuation of the huge belt of natural longleaf originated, and it is instructive to reflect how important fire has been in the ecological story of other valuable forest trees in different climatic regions.

Following upon an examination of the ecological position comes a particularly interesting study of the problems of natural regeneration. The experience of American foresters in

this connexion are remarkably similar to those of others in other countries with other species; so we read that 'deliberate regeneration of longleaf pine has been rarely accomplished. In fact the reproduction of this species has been so irregular and uncertain, and its natural controls so imperfectly understood, that successes and failures have been difficult to explain' (p. 100). But a great deal of information has been collected on such important matters as average numbers of cones per seed tree, periodicity of seed years, wastage factors in seed produced, dissemination distances, root–shoot ratio of seedlings, fire resistance of seedlings at different stages after germination, the relationship between fungal attack (*Scirrhia acicola*) and controlled fire, &c. The question of the preparation of the ground to give the best germination and survival is treated very fully. On the whole the best results are obtained with a soil covering which is not too thin, when birds and rodents find and eat the seed, or too thick, when mechanical interception prevents germination; 'a properly timed burning treatment is the most economical means of effective preparation of seed beds' (p. 99).

It has been estimated that there are about 7 million acres of clear-cut, non-restocking longleaf pine lands, most of which must be planted if they are to be reforested satisfactorily in a reasonable period (p. 119). Thousands of acres have been successfully planted and a lot of valuable work has been done in both nursery and planting technique, but the impression given is that in this direction there is still a good deal to be learned.

Nearly everywhere in the longleaf belt livestock has free range. Very extensive damage to seedlings is done by 'razorback' hogs, so areas must be fenced against these animals; nor is this the only protection problem.

Under the general heading of management an enormous amount of data has been collected regarding growth and yield. It is interesting to find that quality classes based on average height of dominants at 50 years of age are used. The silvicultural system recommended is called clear cutting but, in fact, involves leaving a small number of seed trees per acre. Here again the impression is that, compared with European forestry, management, including silvicultural technique, is in its infancy.

A compilation of information such as this must necessarily become outdated as research and experiments proceed, but the first collection of knowledge has been made and it will be a comparatively easy matter to keep it up to date. We have only to consider how useful and precious would be a corresponding monograph on the Scots pine in Great Britain.

The book is excellently planned and produced. It is printed on lightweight paper and a great many figures and explanatory tables are given without detracting from the text. There are 54 pages of appendixes which include vegetation lists, strength of timber statistics, a great wealth of data regarding growth and yield, and a glossary of technical terms. The very complete bibliography contains 637 references to published articles, and the 45 excellent photographic plates are bound together. A good index completes a very fine book.

The hope is shared with Dean Graves 'that this work will be followed by analogous comprehensive studies of other important species', but it is also hoped that some at least of these will be made in Great Britain.

Forest Soils. By H. J. Lutz and R. F. Chandler. John Wiley & Sons Inc., New York, and Chapman and Hall, Ltd., London, 1946. Price 30*s*.

Review by H. M. Steven

MR. LUTZ is Professor of Forestry at Yale and Mr. Chandler Professor of Forest Soils at Cornell; hence one turns to this book with interest. In plan and treatment it is traditional, and it is entirely different from Wilde's *Forest Soils and Forest Growth*,

reviewed in the last number of *Forestry* (xx, pp. 88–9). To some extent the books are complementary.

The chapters are entitled: soil-forming minerals; soil-forming rocks; disintegration and decomposition of minerals and rocks; forest soil organisms; organic matter of forest soils; nature and properties of soil colloids, and general physical properties of forest soils; water relations of soils; general chemical properties of forest soils; soil formation; forest soil classification; and soil erosion and forest soil deterioration.

The general method of treatment is thus to discuss soils from different points of view, and as a rule at the end of each section to consider the ecological and forest relations of that aspect. Therefore one does not get a clear picture of soils as one finds them in the forest, and their relationship as a whole to the forest, and vice versa. Similarly, while there are references to soil problems in nurseries in various places, there is no general discussion of this important subject. Nevertheless, there are excellencies in this book. The chapters on soil-forming rocks and minerals give a useful summary of this large subject. The clay minerals are dealt with in the chapter on soil colloids, and it includes reference to the recent use of the electron microscope in their study. The chapter on physical properties of forest soils is good, and is clearly a subject in which the authors are interested. There is also a lucid discussion of water relations of soils, including reference to recent work on pF.

It appears curious to the reviewer that the early chapters are on minerals and rocks and their disintegration and decomposition, but one has to wait until Chapter XI for the discussion on soil formation, and the clay minerals are met with in between. While there are objections to any sequence, it has always appeared to the reviewer that a study of soil development and soils as they are met with in the field forms the best introduction to the detailed study of different aspects. The concluding chapter is on soil erosion. A good summary is given of both the immediate causes and control of erosion, but one cannot deal with this large subject in a chapter. It might have been better to limit the discussion to the purely soil aspects, for example the soil factors making for erosive characteristics.

There is a long list of references at the end of each chapter. This adds to the value of the book from the point of view of the senior student; but it is indicative of the large volume of published work on the various subjects that one misses citations one considers to be relevant.

To conclude, one cannot call this a stimulating book, but it will be very useful for reference, particularly in some parts of the field covered.

Soil Fertility, Renewal and Preservation. By E. Pfeiffer. [Pp. 196.] Faber & Faber, London. 1947. Price 12*s.* 6*d.*

Review by G. K. Fraser

THE reviewer has approached this volume with that 'open . . . above all . . . humble mind', &c., which E. B. Balfour postulates in the Introduction as characteristic of the true scientist—at least in so far as he found it possible after reading the introductory pages. The substance of the book may be described as an account for the ordinary reader of the biodynamical approach to farming and horticulture.

In view of the present controversy between advocates of organic (compost) manures and those who use the so-called artificial fertilizers, the reviewer may be excused for affirming his belief in the use of organic manures for the maintenance of soil fertility; and he has no prejudices whatever against the use of any substance which can be shown to improve or maintain the fertility of the soil, whether organic or not. Like most people he

is aware that large tracts of the earth's surface have become infertile as a result of (amongst other factors) improper agriculture, e.g. the neglect of soil organic matter. This has occurred in recent times in spite of warnings from advanced scientific opinion, as well as in ancient times when scientific guidance was completely lacking.

But it is a far cry from such beliefs and knowledge, based on careful observation and measurement, to the philosophy upon which this book is based. Quite a considerable amount of the material it contains can be called fact in the sense that it is generally accepted by well-informed contemporary opinion, and based on long practical experience as well as carefully conducted scientific work. Even some of the more philosophical matter it contains may have a foundation in fact. But nowadays the philosopher should become acquainted with the material facts of his subject and the basic structure with which they provide him. The scientific background here presented is characterized by complete lack of cohesion and balance—is in fact strangely reminiscent of a poor quality examination paper in its want of comprehension of the matter presented. For example, 'The process of nitrogen fixation by bacteria is well known. May it not be possible that a similar process exists in the case of phosphoric acid? This is a question which deserves investigation and research' (p. 40, l. 13). Such an example of loose wishful thinking is incompatible with even an elementary knowledge of either chemistry or soil science, and has been quoted only as illustrating the large amount of absurd argument and use made of science throughout the book.

Stated shortly, the biodynamical system of philosophy seems to be based on the thesis that 'life and growth (are) an organic whole over the entire earth'. From this thesis we are led on to the idea that of this life and growth the soil is an integral part, and (it seems to the reviewer) in turn we are to believe that the soil is the only gateway, so to speak, through which matter of non-organic origin can enter the stream of life as food for plants and in turn for animals. It would appear, too, that the atoms of nitrogen, phosphorus, and potassium, &c., undergo in their passage from mineral via micro-organisms to plants and to animals some sort of fining or uplifting process, so that when returned to the soil in this higher state they have greater vitality and health-giving properties than the same atoms applied to soil in the form of artificial fertilizers. On this account organic fertilizers (called natural) should be used, not artificials which are regarded as of inferior status. Because of this organic unity of all life due regard must be given to all the organisms which play a part in the 'biodynamical' cycle.

This is no doubt a pretty, poetic concept, but in the light of fact is without foundation, either scientific or practical. Scientifically not one line of proof is presented for it here—in spite of the so-called experiments and collected data presented in the book. No one would wish to deny the success of some of those who practise compost (organic) manuring, and there is little to object to in the sections dealing with compost making and using, apart from the frills. The value of the composting system lies in the great likelihood it gives to the non-scientific farmer of achieving by practical methods a reasonably well-balanced manure, in addition to maintaining the 'humus' supplies of the soil. In this way the whole of the success of organic-manuring practice as well as (on similar lines) of the animal-feeding experiments quoted can be commended without undue calls on the imagination, whether these practices are called biodynamical or not.

On the other hand, the soil is *not* 'a living organism' but a medium on and in which organisms live. The atoms or molecules collected and sorted out by bacteria, or plants, or animals are not as such specially endowed. Humus is as dead as are the limestone cliffs of Dover, though both are biotic in origin; both humus and lime are necessary for soil fertility in general, and neither is used as such either by plants or by the majority of soil organisms.

If by soil is meant the organisms it supports, then the rotting carcass of any animal is more of a living organism than is the soil. Expressions like 'the soil is a living organism' may be valuable in emphasizing the complexity of the ecology of the organisms which live in soil; as part of a practical philosophy they can easily become superstitions, such as glorification of the soil, of earthworms, bacteria, fungi, and the like. One of the advantages to the philosopher of such a philosophy as this is that it enables him to make use of or reject, as suits him, any scientific discoveries or suggestions which are not fully understood or for which data are, so far, not sufficiently wide to permit of scientific generalization. Thus there are presented analyses of plants to show their relatively high content of iron, magnesium, &c., and cryptic conclusions are reached from these analyses. The figures given are doubtless reasonable, and iron, magnesium, &c., may be shown to have special functions in plants and in animals. Again the presence can be demonstrated under certain conditions of those substances to which the names of vitamins, hormones, or plant growth substances are all too loosely applied, both inside and outside of living matter. But it is quite another matter to evaluate their possible significance in the soil or even in the compost heap (which by the way is a wholly artificial structure), and it has not yet been shown that external organically bound iron, &c., or 'growth promoters' have any beneficial effect on the growth of the natural plant; the responses which have been conclusively demonstrated result from application to injured plants (cuttings, &c.). Unwarranted claims for substances of this kind seem to form a considerable amount of the fighting power of the biodynamist, and because of recent scientific progress in appreciation of the catalytic power of small amounts of reagents, we are presented with all sorts of possibilities of this type of reaction based here on an incorrect definition of catalyst. 'A catalytic substance aids a chemical change but remains itself unchanged in the process.' Quite different from the true definition in which the catalyst is described as undergoing no *permanent* change. For example, water passing into the boiler of a steam-engine, being boiled, driving a piston and making the wheels go round before becoming cooled to water again undergoes no permanent change, but to describe it as remaining 'unchanged in the process' is nonsense. As with water in this physical example, so with the catalyst in the chemical sphere. All catalysts change in some way during the process which they accelerate. There is nothing miraculous about them, however essential to life, useful in the home, or profit-making in the factory they may be.

We have mentioned this point here because badly digested science of this kind seems to form an essential part of the biodynamical scheme, leading to the preparation of fertilizing solutions (possibly from plants—the reviewer cannot verify this origin from this book with any certainty), which seem to form the special tools of the biodynamist. As regards these preparations about which 'apparent secrecy' is observed, the reviewer can pass no opinion, even *apparent* secrecy being opposed to the scientific outlook. But a common-sense view arrived at from the general trend of the later chapters of the book, with its imitation scientific tests, its physicians' reports, and the like, are too reminiscent of the Victorian cure-all patent medicines to encourage any belief in their value or in the judgement of their advocates. Until tested by impartial and scientifically conducted investigation they can be regarded only as quackery.

The subject of plant nutrition—let alone animal nutrition, into which the biodynamist also rushes—is sufficiently complex in detail without surrounding its perfectly well understood general features with esoteric fog, derived from medieval philosophy and decked out with distorted scientific data. Certainly the author of this book has neither the knowledge nor the habit of mind to deal critically with the science he makes use of any more than with that which he aims to replace.

To foresters we ought to mention that in Chapter IX the author comments for seven pages on forestry with the same lack of balanced understanding apparent in the rest of the book, here rather more difficult to follow in places on account of inferior translation.

Forestry and Woodland Life. By H. L. Edlin. Batsford, Ltd., London. 1947. 176 pages; 170 illustrations; glossary and index. Price 15*s.* net.

Review by M. L. Anderson

In writing this book the author had a twofold objective, namely, to present firstly an outline for the layman, and secondly a summary for those concerned with forestry work, of the science and craft of tending woodlands as at present practised in Britain. His avowed aim was not to add another text-book to the existing list, but rather to explain forestry in simple terms to all who are interested in it, professionally or because of its importance in relation to other occupations. He also suggests that the book may be helpful as an introduction to the subject for those who hope to study it more intensely.

To achieve such a twofold object successfully is by no means an easy matter. There is always a grave risk that the author may fall between two stools. He may be somewhat too technical for the layman and perhaps not sufficiently precise to satisfy the technician, especially in an enterprise covering so varied a field as forestry. Mr. Edlin has been successful in not producing a text-book and there is little doubt that his book will appeal much more to the layman than to the forester. He has succeeded in compressing into this volume a mass of detailed information on forestry and woodland life culled from a wide range of material and covering every aspect of the industry and of the interest, and he has taken great pains to be correct in his details. What he has accomplished in effect, however, is the writing of two books, one on woodland life, comprising Chapters I to XI and Chapters XXIII and XXIV, and the other on forestry practice, consisting of the remaining chapters; nor has he succeeded in blending the two very skilfully. Apart from that apparent defect, the arrangement of the subject-matter is good, with ample, clear sub-headings, although the work is marred by occasional repetitions which are probably inevitable in any attempt to achieve two aims at once. Moreover, because it is extremely difficult to find one style well adapted for all shades of public taste, and because it is simply not possible for one individual to be expert in all branches of forestry, there is a considerable degree of dispersion about what is on the whole a high average standard of writing. Sometimes, especially in the thirteen chapters primarily concerned with woodland life, he rises to considerable heights of literary achievement, particularly in the last chapter, which is excellent in its way. At other times he writes in an unusually concise, staccato, yet involved manner which often makes him difficult to follow; and it is probable, even in these enlightened times, that too many detailed technicalities, especially when combined with a lack of lucidity, may fail to appeal to the layman. Some of the minutely detailed descriptions of such operations as tree-felling are easy for the forester to follow but may convey little to the layman. The simplest word is, however, the most difficult to define and the simplest action to describe. On the other hand, the book should have a stimulating and refreshing effect on the professional forester.

The readers of *Forestry* are in the main professionally interested in the subject and are perhaps most interested in the adequacy or otherwise of the material intended in the first instance for their benefit. It can be said at once that while it presents a thoroughly satisfactory picture to the layman of the work of the profession, it is less successful in its secondary object. If anything it would have been improved by the omission of some of

the technical matter which is sometimes—and necessarily so in such a publication—rather sketchily dealt with.

The weakest chapters of the technical portions of the book are those dealing with mensuration, forest management, and forest economics, but perhaps Mr. Edlin could rightly claim that they are a fair representation of the position in Britain to-day, in respect of these subjects. There appears to be an unfortunate slip in the calculation given on page 145. The expression 'superficial volume' is puzzling. The section dealing with the measuring of standing trees is by no means easy to follow, there being some risk of confusion between total and timber heights. The sampling example on page 149 is not a very happy one. The examples of dimensions and quantities on page 151 should have been left out, as they are much too generalized and may be misleading. A total yield of 10,000 Hoppus feet per acre is exceptional and by no means usual. With establishment and tending costs so high at present, can it truly be said that the value of a crop often exceeds the comparable return at compound interest for a period of years? Assuming that £30 per acre is the average cost of establishment and initial tending, from his own table Mr. Edlin would expect this to amount to £72 in 30 years and to £99 in 40 years, if invested at 3 per cent. compound interest. How often would he secure a gross return—let alone a net return—of £72 or £99 per acre from stands of 30 or 40 years of age, respectively, not to speak of younger ages?

The chapter on forest nurseries is rather indefinite and inadequate on many important points from the technical viewpoint. The fundamental reason for the simple operation of transplanting might have been given more clearly. The chapter dealing with British forest history displays the usual weaknesses in the usual periods, which is not the fault of the author.

One or two suggestions might be put forward in respect of other parts of the book. More might have been made of the distinctions between the two native birches and between the two oaks. The impression is given on page 18 that larch was first introduced to Britain in 1725. The author knows, however, that such was not the case. In his chapter on forest soils, which is not very satisfying, there is no reference to the importance of glacial geology in this country. Nor is there a true appreciation of how extremely serious our usually wet snow can be, causing damage to stands over very wide areas. It is doubtful if gorse-covered land would give the high returns suggested. There are, moreover, two distinct types of gorse vegetation, one indicative of very poor sites. It is by no means exceptional for squirrels to cause serious damage to tree-tops by girdling the bark. Apart from rabbits, no other living agent—except man, of course—has done more serious damage to conifers in recent times. Many virgin forests are even-aged. A reference might have been made to the planting of standards in coppice-with-standards as having an important effect on the composition of existing woodlands.

In spite of this selected sample of apparent defects, this book meets a real need. A little pruning here and there and a little 'beating' in places would doubtless greatly improve it, but it should certainly be very useful to the student of forestry as an introduction to what he hopes to make his life-work. And Mr. Edlin has indeed painted a rosy picture of the prospect before the tyro. The thorns, and they are not a few, are skilfully concealed.

The appeal of the book—and it is worth having for this alone—is very much enhanced by the numerous, mainly excellent and apt, photographic illustrations which the author has gathered from many sources—all indigenous. But why the choice for frontispiece of the by no means beautiful, by no means appropriate, and by no means well-produced, coloured picture of Corsican pine shoot, flower, and cones?

Mr. Edlin is to be congratulated on the stand which he takes in his preface on behalf of

British forestry and on the success with which he has built up a valuable book on native materials; but surely it is long since our 'scientific forestry' reached a stage when its theories might be based on the practice in its native land! Might one also suggest that the omission of his remarks on Irish forestry would strengthen his position as a British exponent? It would be an interesting study to compare the technical information given by the author with that given in Grigor's admirable text-book on Arboriculture, published in 1868, and with that in the first edition of Brown's *Forester*—1847, not 1860—with a view to determining how, if at all, and in what way, the technique of British forestry has radically altered or improved in the last century. Mr. Edlin's new production has an added value in this connexion in that it takes its place as the latest literary signpost on the road along which British forestry is moving.

Perhaps the greatest service which Mr. Edlin does us is to remind us of the numerous and varied facets of our subject and that in our profession we are concerned with the production and control of living things in a complicated association and not with machines; that we are dealing with the unpredictable and with something greater than ourselves, which does not lend itself readily to rectilinear geometrical design nor to treatment according to rigid mathematical formulae. It is when Mr. Edlin forgets this that he is least satisfying.

Our Forests. By W. H. Rowe. Faber & Faber, Ltd., London. 1947. Price 12*s.* 6*d.*

Review by J. Alan B. Macdonald

MR. ROWE has written this book, he announces in the Preface, for three reasons: (*a*) because the public are so ignorant about forestry; (*b*) because forests contain so much of interest; and (*c*) because forestry is of vital national importance. Three excellent reasons. He has tried, therefore, he goes on to say, (i) to give a broad outline of forestry; (ii) to give sufficient elementary information 'to make the book of some practical use to the non-expert'; and (iii) to present his story in an interesting way to the general reader. Now (i) and (iii) are logical outcomes of the treble purpose behind the book. (ii) is perhaps in some ways unfortunate, for is there not too wide a gap between the general public's almost non-existent knowledge of forestry and the knowledge of the forest-owning non-expert for any single volume to attain success as a treatise and as a junior text-book?

The book is attractively produced and plentifully illustrated with well-chosen photographs. It begins with an essay entitled 'Magic of the Forest'. Man's relations with the forest are traced from the first fearful and stealthy intrusions until he becomes its master and finally its preserver. Our dependency on forest produce is mentioned, but the writer passes on quickly to the aesthetic aspect: 'The forest as it stands in all its glory lending beauty to the landscape—an enchanted world to those who walk therein with a seeing eye and an understanding heart!' Chapter II, 'A Glimpse into the Past', traces the forest's history from Silurian times through the succeeding geological periods to the Ice ages, into historical times and right down the years to the end of the First World War; and Chapter III, 'To-day and To-morrow', brings the reader right up to date by discussing that relatively short period since the inception of the Forestry Commission as the forest authority in Great Britain. Afforestation by the State between 1919 and 1939 of 368,878 acres is applauded as a considerable achievement. The author, however, deplores the failure of the Forestry Commission to do anything really effective for private estate forestry, and the failure of private estates to do much forestry for themselves during that period of increasing insecurity. The Commissioners' report on Post-War Forest Policy represented

a definite step forward; and a footnote added in July 1946 brings the chapter more or less up to date with a comment on the Forestry Act of 1945 which reconstituted the Forestry Commission. The writer's final remark is to the effect that the scheme still requires clarification on many points.

In Chapter IV, which deals with 'The Forester at Work', the author first classifies woods according to three degrees of stocking—sparse, well stocked, and overstocked. To this he adds an over-mature class. He discusses sensibly and simply such things as coppice, natural regeneration, the clear felling and replanting system, the selection method, and the ideal of regularized yield. Then come two sections with sub-titles in large capital type which shock the reader into realizing that this is after all only a text-book and not the pleasant smooth eminently readable book he was beginning to enjoy. Indeed, from here on the work degenerates rather into a text-book, albeit quite a good text-book. Chapters V, VI, and VII deal with 'The Birth of a Forest', or rather of a plantation from the sowing of the seed to the planting of the young trees. Chapter VIII discusses the subsequent care of the forest. All through these chapters the introductory paragraphs are simple and readable, and one cannot help wishing that their style had been maintained throughout. As it is, chapter after chapter becomes sooner or later so subdivided by classifications of all sorts, e.g. types of soil, lists of species, and types of mixture, as to become practically a reference book. Of these chapters 'Caring for the Forest' is the most readable, but even in it there is a tendency to overdo the amount of detail. This makes heavy reading for the public, ignorant of forestry, the public for whom, after all, Mr. Rowe set out to write.

The inevitable chapter on forest enemies is interpolated at this point and is well done. One is glad to see the rabbit menace driven home. Then comes a nicely written account of 'Harvesting', and an attempt (Chapter XI) to discuss 'Some Financial Considerations', introducing examples with compound interest. Once again a less detailed account might have got the forester's or forest owner's economic worries across to the general reader more smoothly. Chapter XII is a catalogue of the broad-leaved trees and Chapter XIII of the coniferous trees. One cannot imagine a member of the uninitiated public or even a non-expert reading these through, although the non-expert, if he possesses no more complete reference book on trees, might learn quite a lot to his advantage therein. 'Timber and Its Uses' (Chapter XIV) is again altogether too much the text-book or reference book.

Finally comes Chapter XV, 'What of the Future?' another excellent and readable essay. In view of the speed with which current legislation is being passed, it is little wonder that many of the suggestions Mr. Rowe makes for the better administration of forestry, and especially private estate forestry, in Great Britain have already been adopted. The writer points out that forests and forest industry are 'essential parts of the structure of rural life and economy' and comments on the necessity for developing a true forest sense among our people. He stresses the need for co-operation between the interested parties, landowners, forest workers, timber users, research workers, the Forestry Commission, and the State 'which eventually means each one of us'. He has no doubt that the State will proceed with the programme of creating new State forests and managing them, but believes no plan will be of much use if it fails to deal effectively with private woodlands which still form the bulk of the forest in the land.

The need for a strong will to succeed and for political and economic stability, if sound forests and prosperous industries are to be founded, is stressed. While admitting the need for centralized control and 'the State alone has the necessary authority, power and resources to make it effective', the writer pleads for the maximum amount of freedom for the private estate. He believes that the independent forestry societies can do a great deal for forestry. To the young readers who may be enticed by the 'Magic of the Forest' to enter upon

forestry as a career he offers no easy life but rather 'toil, patient striving, often followed by disappointment and frustration, isolation sometimes and exposure to many kinds of weather'. But he will be compensated by the healthy and active life, variety, 'an opportunity to express and expand the finest qualities of mind and body, an occupation which never lacks interest and, above all, the satisfaction which comes from doing a worthwhile job'.

The book concludes with a warning—our forests are a national heritage and an asset which must not be neglected. Their restoration to full productive capacity and the creation of new forests are matters which affect every citizen, even if his 'part be limited to an intelligent understanding of and sympathy with the problems involved'.

Forestry and Forest Products: World Situation 1937–46. (A report by the Food and Agriculture Organization of the United Nations, dated 15th August, 1946, printed in English at Stockholm; presented to and approved, subject to minor changes, by the Second Session of the Conference of F.A.O. at Copenhagen, 2nd–13th September, 1946.)

Review by the Editor

THIS report throws much light on current shortages of wood and pulp and the often debated question of whether the world's forests are being exhausted or not. It deserves study by all foresters, timber traders, and consumers of wood and pulp, in fact by everyone who can read and look ahead.

The main conclusion is that there is more than enough forest soil to provide wood on a sustained yield basis for the peoples of the world, even with rising populations and standards of living; but that the present attention to conservation and sound use of forests is very far from adequate, and action to save the situation is urgently necessary. Grave shortages of accessible trees and forest products already affect great parts of the world and many millions of people; and such shortages threaten to become worse unless common sense is applied to the problem, that is, unless sound forestry is practised.

It is to be hoped that those who have encouraged complacency by references to the untapped forests of Siberia, Canada, the Amazon, and West Africa will face up to the situation described region by region in this report, and the supporting evidence now available from many independent sources. There is no cause to despair of wood or the possibility of adequate sustained supplies for essential purposes and to compete in legitimate fields with other materials; but there is every reason to wake up, to conserve the natural forests still left, to re-stock the derelict or half-stocked forest soils, to improve silviculture and utilization, and to strive to provide adequate forest products at reasonable cost for all peoples.

The position in Great Britain after two great wars and blockades is familiar to British foresters. The urgent need for action in the United States, British Columbia, and other parts of North America has been examined and reported on by government and private authorities in those regions very recently. Those who know China, India, Burma, Africa, and other tropical countries are familiar with rapidly growing populations, destruction of forest by shifting cultivation, growing or prospective demands on forest reserves, and surprisingly rapid exhaustion of forests not legally protected. Australia faces shortages. From the U.S.S.R. there are reports that in future the more accessible forests will be occupied with domestic needs, therefore exports must come from the great but more remote forests of Siberia. There is good reason to believe that the broad world picture of the F.A.O. report on forestry and forest products is correct.

Sir John Boyd Orr, Director-General of F.A.O., writes as follows in his preface to the report:

'Some of the causes of the present wood scarcity, such as insufficient manpower, disorganized transportation, and inadequate equipment, are temporary factors and bear little relation to the existing supplies of wood or to the productive capacity of the forests. But the underlying causes of the world's chronic wood shortage are basic and have been exerting their pernicious effects for decades.

'These basic causes include deforestation, inadequate forest management, failure to develop mature forests, incomplete utilization, and insufficient technical personnel. . . .

'At least two thirds of the human race use wood for cooking food, and to that extent wood itself becomes an integral part of the world's food supply. In many parts of the Far and Middle East, fuel wood scarcity is a critical agricultural problem. . . .

'If we are to create a world where famine will never again be known, the restoration, protection and rational use of the world's forests are indispensable. But man's need for forests does not end with his need for food. Beyond its role as protector of crops and conserver of water, the forest is the factory that produces earth's foremost renewable resource—wood.

'Wood is shelter and warmth. It is the paper you hold, the book you read. It is the world's most versatile raw material. . . . The chemical possibilities have barely been touched, and fibre chemistry is opening up an entire new field of plastics and textiles, and permits the economic pulping of almost any wood species and of much waste from the sawmills. . . .

'Faced with an ever-increasing need for forests as allies to agriculture and producers of a material serving unnumbered human uses, the Food and Agriculture Organization cannot look on indifferently while year by year the world's forests deteriorate in quality and shrink in area and volume.

'So long as famine treads the world, the first obligation of the Food and Agriculture Organization is very clear. Our immediate task is to increase the available supply of food; our long-range task is to create a world better fed and better sheltered through a wiser use of land. And for both these tasks, we must call upon an indispensable ally of agriculture—the forest.'

There are differences of opinion on the proper functions and practical possibilities of F.A.O. at the present stage of human development. Whatever views one may hold on possible action and how it should be taken, it is clear that any plans, national or international, will be helped by skilled estimates, as reliable as possible, of the world's forest resources, the best possible collection and analysis of data on past consumption of wood, current supplies and current and future needs; and by the interchange of technical information on silviculture and utilization.

The British Empire has held five Empire Forestry Conferences between 1920 and 1947, with very valuable results. A common language and a large measure of common ideas and ideals have made these conferences much easier than world conferences can be at present. It is plain, however, that modern developments have increased the urgency of overcoming the difficulties of international co-operation, and it is in this vital field that F.A.O. works. It deserves full support if its service is efficient, disinterested, and reliable, in fact worthy of its great task.

The report under review is well arranged and written. It is in three parts, dealing with (1) the Forestry Balance, (2) the Forest Products Balance Sheets, and (3) Conclusions and recommendations. The last part is compressed into three pages.

Space allows only brief references to some outstanding points. The difficulty of estimating

annual net growth is shown by the case of the Soviet Union, where one source puts it at 500 and another at 250 million cubic metres of roundwood. The recovery of usable wood from a given volume of roundwood is much higher in France and Sweden, for example, than in the U.S.A., and this affects the real value of the *per caput* consumption of roundwood in different countries. The forest areas of the world are estimated to consist of 35 per cent. softwoods, 15 per cent. temperate hardwoods, and 50 per cent. tropical hardwoods; yet 85 per cent. of the industrial demand is for softwoods. Excluding fuel wood the *per caput* annual consumption ranges from 2·0 cubic metres of roundwood in North America to one-tenth as much in large parts of Africa and the Far East, and one-eightieth as much in the Middle East.

Europe, exclusive of the U.S.S.R., is estimated to be overcutting its forests. Reconstruction needs may aggravate this and do more harm than the actual war years. Sooner or later the cuttings must be reduced. Shortages will then be more acute than ever unless imports can be secured.

The forest situation in North America, especially the U.S.A., is described as alarming, owing to continued overcutting and inadequate management. The annual cut has risen from 320 million cubic metres of roundwood in 1936 to 365 in 1945. The annual growth is estimated as steady at 250 million cubic metres. The reduction in volume of accessible timber is estimated at 450 to 550 million cubic metres of roundwood since 1938. It is held, however, that good management could increase greatly the net growth, in the long run, and reduce natural losses by as much as 30 million cubic metres of roundwood a year fairly soon.

> 'The forests of the United States, if properly managed, may eventually support a sustained annual cut of 535 to 560 million cubic metres of roundwood. There is danger, however, that present overcutting may impair the productive capacity of some areas for many years in the future, and could even result in a lasting depletion of the forest resources.'

In Canada the present annual growth is believed to be about equal to the present annual drain, and it is held that better management will sustain or even raise the present output.

The conclusions on Africa are worth quoting, because the welcome prospect of early substantial new exports of plywood and hardwoods from British and French West Africa should not obscure the urgent need for conservation and afforestation, especially of softwoods, in Europe and other regions.

> 'From the long-range viewpoint, looking beyond immediate post-war necessities, it is likely that under conservative management and with more complete knowledge of the utilities of the chief timber species, the forests of Africa may produce not only enough timber to fulfil domestic requirements, but to export fair quantities of special-purpose woods. Little more can be expected, since before the war Africa's timber imports were about five times her exports, in spite of the fact that her *per caput* consumption is among the lowest in the world. Any appreciable improvement in the standards of living would probably at least double this consumption, so it is unlikely that within the predictable future Africa will be a very important factor in the world's timber supply.'

The paragraphs on South America, particularly Brazil, are of special interest. The region is one of the world's great reservoirs of wood. It presents great possibilities and great difficulties. The latter are plain from the fact that the region imports almost twice as much wood as it exports. Inadequate transportation, absence of labour, reluctance of capital to interest itself, and lack of information on the real value and use of the many unknown or little known woods of the region, are named as reasons for the poor use so far

made of the great hardwood forests. (Brazil has substantial softwood forests, also, of Parana pine (*Araucaria angustifolia*), the most extensively worked wood in South America; but supplies to Europe in her present need appear to be hindered by quota controls, lack of railway equipment, and other factors.)

In Part II there is an ominous reference to the danger that once reconstruction has been completed there may be too much lumber in the world unless an expanding world economy lifts consumption to the levels of prospective supplies. Such temporary local gluts have occurred in the past and have encouraged wasteful forest working. They do not contradict the evidence of shrinking forests or weaken the case for sound forestry, but they strengthen the case for the free flow of world trade and the raising of standards of living where they are so low that people cannot buy what they need.

The facts cited about pulp and cellulose fibres made from wood are impressive. They are encouraging to foresters hoping for markets for thinnings and shorter rotations. Wood-pulp consumption rose from 10 million tons per annum at the end of the First World War to almost 25 million tons per annum during the inter-war period. Increase in literacy is only a minor factor. In 1945 the U.S.A. consumed four times as much paper for packing as for printing. The latest figures put world production of various synthetic cellulose fibres close to 2 million tons, or 15 to 20 per cent. of the world's annual fibre supply. For comparison, cotton is estimated at 6 to 8 million tons, wool at 1·6 to 1·8 millions, and natural silk at 60,000 tons per annum.

> 'Recent statistics show that one acre of good forest land can grow annually two to three times as much fibre as the same acre planted to cotton. The price of synthetic fibres has fallen considerably in the past fifteen years, and is so rapidly approaching the cost of cotton that serious competition may develop between natural and synthetic fibres unless plans are made to direct all available fibres into proper channels, i.e., to use increased fibre supplies for higher clothing standards.'

The conclusions of the report have already been outlined. The general recommendations include encouragement of laws to secure sustained yield management of all permanent forests, increased yields per acre by silviculture, orderly development and management of virgin forests, afforestation of denuded forest soils, better utilization and the integration of forest industries, providing enough forest products for adequate living standards throughout the world, more research in silviculture and utilization, and the training of enough foresters and wood engineers.

The specific recommendations for immediate action are:

(1) Regional forest conferences called by F.A.O. for Europe, the Far East, and North and South America, to plan measures to ease wood shortages with a minimum of damage to the forests.

(2) Help and advice by F.A.O. to governments, acting individually or collectively, in emergency measures to deal with the present shortage, such as obtaining logging and transportation equipment, better utilization and accelerated opening up of undeveloped forests.

(3) A world conference called by F.A.O. to agree on definitions and measurement units for forestry statistics, and conversion factors between national data and F.A.O.'s standard terms and units.

(4) F.A.O. to draw up data and balance sheets of forests and forest products for the whole world, and publish a handbook on the subject.

In the concluding paragraphs it is recognized that the initial steps towards a world forest policy must be taken within each country, and F.A.O.'s task is to compare and analyse these national programmes, suggest ways of improving them, and aim at co-ordination, first

on a regional and ultimately on a world basis. Planned management and use of the world's forests and forest soils is held to be the only way to avoid temporary wood shortages and surpluses.

It is a far cry from such a scheme to the haphazard destruction and use of forests in past centuries, and the still relatively small-scale practice of sound forestry in the world as a whole; but the results of past neglect are such that everyone will wish success to national and international action to retrieve the situation. Some progress has been made. Much remains to be done.

NOTICES

Forestry. By H. L. Edlin. Young Farmers' Club Booklet No. 20. Published by the Pilot Press, Ltd., for the National Federation of Young Farmers' Clubs.

THIS well-illustrated booklet of about fifty pages is a praiseworthy attempt to inform and interest the public in forestry. In it a bird's-eye view is given in a simple and readable style, and the thirty-two illustrations are well chosen and clearly reproduced. It appears to be designed, however, for the general reader rather than Young Farmers' Clubs. If appeal was to be to the latter, one would have expected that forestry in relation to agriculture in Britain would have been the keynote; it is scarcely mentioned. Admittedly this is a subject which has not yet been fully thought out, but it is of great importance. The whole question of shelter in relation to animal husbandry calls for careful consideration both by the agriculturist and the forester. At present it is not receiving much attention from the official bodies connected with either. Secondly, the number of agricultural owner-occupiers in this country is not inconsiderable, and what Americans call farm forestry deserves more attention. Finally, there is the thorny problem of the respective spheres of agriculture and forestry on the hill country. The only brief reference to this problem on page 6 will probably be considered *ex parte* by the informed agriculturist. It would have been an important contribution if these subjects rather than forest nursery work and afforestation methods had been discussed in this publication intended for the young farmer.

Mr. Edlin has considerable gifts as a popular writer. There are a few blemishes of a technical nature but these are not important from the point of view of the general reader. Incidentally the stand figured on page 11 was felled in the First World War, and the volume was twice that stated, as could be ascertained from Forestry Commission Bulletin No. 10.

The publication should be made available to the general reader, because it should appeal to him, and especially to scouts, guides, and others who are or should be interested in the country-side.

H. M. S.

Knot-free Red Pine by De-budding. By A. Bickerstaff. Silvicultural Research Note No. 76. Dominion Forest Service, Canada. 1945. 10 pp.; 4 charts; 1 illustration.

THIS paper, which is very detailed, reports the results of an experiment carried out on *Pinus resinosa* in Canada to test the effects of removing the lateral buds annually when the tree is a few feet high so as to produce a tree which has branches on the lower part of the stem, a completely branch-free length for the next 18 feet, and a normally developed crown above that height. The experiment was suggested by the work done by Krotkevitch at the Kiev Forest Research Institute. Advantages claimed for this procedure over ordinary pruning are that 100 per cent. knot-free timber may be produced in as short a period as from 30 to 40 years; timber production on the main stem is greater; there is no risk of infection by fungi; and it is a simpler method.

The buds are pulled off with the fingers just after they have begun to swell, and as the small scars are at once covered with resin, no injury results. On the average about four living branch whorls are left at the base of the stem.

Careful height, diameter, and volume measurements were made and the data were handled statistically. It is claimed that the treatment stimulated diameter-growth in the upper part of the stem but reduced it in the lower part. Height growth was not appreciably affected. The debudded trees formed longer needles on the terminal shoot and these persisted longer. The operation costs about 1 man-minute per tree each year for 10 years. Some snow damage was done to the lower living branch whorls.

The experiment was carried out in two different plantations, and while the first experiment was satisfactorily replicated, it is not clear that replications to permit of an assessment of site variation were arranged in the second. It would thus, perhaps, have been better to have handled the data for each plantation quite separately and not in combination, as more reliance could be placed on results from the former than from the latter.

Artificial pruning seems at the present time to have become the fashion with experimenters, but we must reserve our opinion on the ultimate results of this lateral debudding until further reports are to hand.

M. L. A.

Fire Control Notes, Vol. 7, No. 3. Forest Service, U.S. Department of Agriculture, Washington. October 1946.

WELFARE of fire-fighting gangs occupies an important position in the organization of fire protection in the States, and much space in this number is devoted to specifications of mobile canteens and their equipment for provision of hot food and refreshments.

Of greatest interest to British forest fire services is the description of a neat little power hose-spray fitted to the standard 'Jeep'.

The mobile trailer flame-thrower for clearing fire-lines or 'slash', using a mixture of diesel oil and butane gas, is suggestive of a cheap means of clearing some of our war-felled areas where the lop and top otherwise will be costly in cash and in man-power.

G. B. R.

Fire Control Notes, Vol. 8, Nos. 2 and 3. Forest Service, U.S. Dept. of Agriculture, Washington. 1947.

FIRE prevention and fire-fighting in Britain are not advancing hand in hand. Our native conservatism has shrunk unreasonably from the wide publicity which is really essential if we are to educate the ever-increasing number of people who are finding their recreation in country surroundings. Fire-fighting technique has been improved during war years, mainly on account of the interest and co-operation of the National Fire Service in combating forest fires. Fire prevention by adequate fire lines, planned layout, distribution of less inflammable species as really wide breaks across strategic parts of the forests, and, above all, prevention by publicity has not advanced concurrently: in fact, owing to war restrictions it has, in some respects, deteriorated.

Fire Control Notes is becoming the recognized medium through which U.S. foresters and forest-fire officers exchange information on technique and machinery. There is some tendency for pure foresters to isolate themselves from fire protection which is more and more becoming the job of fire specialists. A. A. Browne stresses the need for unification. Forest management and silviculture cannot be divorced from fire protection.

A new sulfa compound (2, 4-D) is described by Blanchard for killing 'brush' on fire rides,

but the results so far are inconclusive. Several improved fire vehicles, trailers, and crawler plough equipment are well described and illustrated.

The revival of this journal should become of great incentive value in the United Kingdom as well as in the United States.

G. B. R.

An Extract from *Science*, Vol. 104, No. 2703, Friday, 18 October 1946, p. 377. (American Association for the Advancement of Science. Lancaster, Penn.)

(The following extract is reproduced with grateful acknowledgements to the journal and author concerned.)

Book Reviews

The New Genetics in the Soviet Union. P. S. Hudson and R. H. Richens. Cambridge, Engl.: Imperial Bureau of Plant Breeding and Genetics, 1946. Pp. 88. 6*s*.

Here is a long-awaited and greatly needed study of the extraordinary developments connected with the name of the Russian agronomist, T. D. Lysenko, from which arose the now famous Genetics Controversy which rocked Soviet biology and aroused the interest of the whole scientific world. What was needed was a sober, careful description of the facts and a reasoned analysis of the interpretations which gave rise to the controversy. This difficult task has been accomplished so well by the two British authors that the importance of their book transcends the limits of this particular controversy and of genetics. It is a contribution to the methodology of scientific discourse which may be read with interest by scientists and philosophers generally. Coming as it does on the heels of the appearance of Lysenko's chief theoretical treatise (*Heredity and its variability*. Translated by Th. Dobzhansky. New York: King's Crown Press, Columbia Univ., 1946; see *Science*, 1946, 103, 180), it will hasten and facilitate the judgment of scientists on one of the most remarkable controversies of our time

The study is based on an examination of the original publications, most of them in Russian, in which, between 1932 and 1944, appeared the experimental evidence, theoretical discussions, and polemics of the Lysenko school and its opponents. In addition, the sources of Lysenko's ideas have been traced by reference to the works of Darwin, Naudin, Timiriazev, Burbank, Michurin, and others. These citations, together with a few from modern non-Russian sources, bring the bibliography up to some 300 titles, each with complete listing of author, title, and source in original language and English. There is good evidence that these works were carefully combed and conscientiously used. All important statements attributed to the authors quoted are printed both in the original language (usually Russian) and in English, and much of the critical data are translated and reproduced in tabular form so that these can be judged by those unable to read or to consult the Russian original.

In all of this careful work the authors have maintained an objective, judicial, and respectful attitude against which the charge of prejudice cannot be sustained. For this reason the general verdict of 'not proven', which they pronounce upon nearly all of the claims of the Lysenko school, will command respect both in the Soviet Union and in other countries.

It is surely better for science that Lysenko's claims have now been exposed and rejected after a full and sober examination.

L. C. Dunn

Columbia University

Extracts from *Forestry Abstracts*

THE following items are reproduced by permission of the Imperial Forestry Bureau, Oxford, from their quarterly journal. They include matter of special interest to British foresters, not reviewed or noticed elsewhere in *Forestry*.

Forestry Abstracts is available to British residents at 20*s*. per annum, including postage, from the Imperial Agricultural Bureaux, Central Sales Branch, Agricultural Research Building, Penglais, Aberystwyth, Wales.

Grateful acknowledgements are recorded for the permission to reproduce the items.

Vol. 8, No. 3, 1947

[1692]. 2:02.1:32.29.2. Hawley, R. C. *The Practice of Silviculture*. John Wiley & Sons, Inc., New York. Chapman & Hall, Ltd., London. 5th ed., 1946. Pp. 354. Price $4.00.

The first edition of this book was published in 1921 and the fourth in 1937. It is written as a school textbook in silvicultural practice and does not deal with silvics, i.e. the fundamental laws underlying the growth of the tree and the forest. It covers the art of producing forest crops but does not go into detail for each of the 100 or more important tree species of the U.S.A., except for the purpose of illustrating principles and procedures by specific examples.

Although silvicultural practice in the U.S. is still in the developmental stage, it can be introduced with a varying degree of refinement even under discouraging economic conditions. Production in managed and unmanaged forests, and the cost of silviculture in relation to utilization are therefore discussed at the outset.

After a general account of the treatment of the stand during the regeneration period, the following methods are described in detail: clear cutting (with artificial and natural reproduction), seed-tree, shelterwood, selection, coppice and coppice with standards. Thinnings and cuttings are grouped mainly according to purpose and methods of control; the need for, purpose of, and cost of pruning are discussed at length; the importance of slash disposal is reflected in the 25 pages devoted to it.

After each of the main subjects a list of references to literature is given. The book is illustrated with diagrammatic line drawings and graphs and there are no photographs.

[1716]. 22.13:57:23.1 (494). Badoux, E. *Le Résultat de trente ans de coupes progressives au Malvaux de la ville de Bienne* (*Liesisbrunnen*). [*The result of 30 years of Swiss Femelschlag fellings in the Malvaux forests of the town of Bienne* (*Liesisbrunnen*).] *Schweiz. Z. Forstw.* 97 (11), 1946 (489–96). [F.g.] [Institut fédéral de recherches forestières.]

In 1915 two plots were laid out near the lower limit of the Jura Beech forest in a stand derived from gappy natural regeneration of Silver Fir beaten up with planted groups of Spruce and formerly treated by regular crown thinnings. There was no essential difference in the initial stocking of the plots. Since 1915, operations have recurred at 5-year intervals, consisting in (*a*) grade B–C low thinnings in one plot (control), and (*b*) Swiss *Femelschlag* (refined group) fellings designed to secure and extend regeneration in groups, with selective thinnings and fellings for light increment on the older trees, in the other.

Results so far are clearly in favour of (*b*), where it has been possible to obtain and control regeneration without current increment falling below that of (*a*). Growing stock is now 720 cu. m. (45 sq. m. basal area) per ha. in spite of the removal of 597 cu. m. (44 sq. m. basal area), while the control contains 1,018 cu. m. (66·8 sq. m. basal area) per ha. and 232 cu. m. (18 sq. m.) have been removed. Mean annual increment has been 21·0 cu. m. per ha. for (*b*) and 19·6 for (*a*). Increment has been concentrated in (*b*) on to half the number of stems and the volume of the mean stem is half as much again as in (*a*). Current basal-area

increment of Silver Fir has been much better than that of Spruce; in addition, the latter suffers from butt rot in middle age. Selective thinning in (*b*) has rid the plot of all very defective dominant and codominant trees and brought down those poorly formed but capable of yielding timber to 7 per cent. (21 in the control), while 43 per cent. of the stand (30 in the control) is in first-grade stems.

Stand (*b*) now has a large number of regeneration groups in various stages of development, and the gradual progress of regeneration facilitates manipulation. Advance growth of Beech covers the ground before any considerable opening of the overwood has been made. Gradual extension of the groups also prevents hardwoods from taking over completely: both Silver Fir and Spruce regeneration come in and are encouraged, where necessary, by removing or topping the competing hardwoods. Tending operations in the young growth are frequent and the forest is being slowly converted to storeyed structure and group mixtures which should give the desired basis for selective treatment.

[1733]. 23.2:12.26–8. Ullén, G. *Ett par synpunkter på askodling.* [*Notes on the rearing of Ash.*] *Skogen* 33 (19), 1946 (294–5). [Sw.]

Ash seed taken in September, when not quite mature, appears to give the best germination. Seed should be taken from parent trees of good growth and form, but female trees of good form appear to be rarer than males [cf. *For. Abstr.* 8 (No. 98)]. Ullén recommends sowing in the nursery as soon as the soil is dry enough in spring, in strips 6–7 cm. broad, 1 cm. deep, and 20 cm. apart. A thin layer of Spruce brushwood may be advantageous as shelter where there is risk of drought. Nursery stock must be at least 1 m. high when planted out under shelterwood at a spacing of 1 m. or a little wider.

[2073]. 42.21:11.11.2. (410). Day, W. R., and Peace, T. R. *Spring Frosts, with special reference to the Frosts of May 1935. Bull. For. Comm., Lond.* No. 18 (2nd ed.), 1946. pp. III+plates.

Experience during the 9 years since this bulletin was first published has fully confirmed the importance of frost as a cause of disease in trees in Britain. The exotic conifers have continued to provide the more extreme examples of susceptibility among species of economic importance. The inspection of plantations has, also, continued to reveal the importance of topographical position as a factor determining severity of injury. Further information is now available on the conditions under which low night temperatures develop, and the influence of the soil-cover type on them. The importance of the stage of development of the species at the time of freezing has been confirmed. Fresh evidence is available on the formation of frost pockets in afforested country. The importance of genetical constitution in determining resistance to frost injury was suggested many times, after the May frost in 1935, by the variability in degree of injury among individuals of one species growing in similar situations. It was particularly obvious with early- and late-flushing Norway Spruce and the various strains of Larch. Experimental plots of European Larch in England and Wales, containing strains of different provenance, confirm the relative resistance to frost injury shown by strains of Scottish provenance as compared with those obtained from the Continent. Alpine races of Swiss and Italian origin have proved to be most susceptible. Evidence has accumulated which stresses the importance of frost injury as a cause of canker on Poplars. Clear instances of frost canker have occurred on *Populus robusta*, *P. serotina*, *P. eugenei*, and *P. candicans*. In some cases serious die-back also occurred. It is strongly suggested that, at least in some cases, pathological developments of this type, which have in the past often been ascribed solely to parasitic action by either fungi or bacteria, are initiated by frost injury even though a parasite may be necessary for the continued and

characteristic development of the disease. The die-back and canker of European Larch is to be regarded in this light, as a disease in which frost is the primary cause of injury, the fungus acting as a secondary factor which stimulates frost susceptibility. Corsican Pine also is subject to serious die-back owing to frost injury. *From authors' introduction.*

Vol. 8, No. 4, 1947

Leading Article

Practical Forest Genetics in Sweden

'SWEDISH research in forest genetics has achieved a considerable international reputation through the work in progress under the Forest Tree Breeding Association (*Föreningen för växtförädling av skogsträd*) at Ekebo and the various branch stations in different parts of the country. Less well known outside of Sweden is the work of the Society for Practical Forest Tree Breeding (*Sällskapet för praktisk skogsförädling*, at first known as *Sällskapet för skogsträdsförädlingens främjande*), which was formed in 1940–41—on a characteristically Swedish pattern—by a number of central- and north-Swedish forest industrial companies in conjunction with the Gävleborg County Forestry Board, and on the initiative of Dr. Bertil Lindquist, who has recently been appointed Professor of Silviculture in the State Forestry School after holding successive lecturerships there since 1931 in botany and silviculture, has made special studies of the variation in crown form and timber quality of Scots Pine in Sweden, and has acted as the scientific leader of the Society since its foundation. The Society's chief aim is to make early practical use of genetical knowledge and principles, and Lindquist has written a book[1] which is summarized in the following notes, and which, being intended to complement the adequately publicized pure research in forest genetics, intentionally disregards this aspect in favour of an examination of practical measures that can be applied at once, and the possible effects of a successful tree-breeding programme on future silvicultural methods and national economy.

'From the start, Lindquist emphasizes the scantiness of rigorously established genetical facts on which a breeding programme might be based, but sees no reason why the strong probabilities offered by phenotypic variation should not be used at once, subject to constant control by progeny trials. Past breeders of both plants and animals have successfully used phenotypic quality as an index to genotypic quality, but it will appear in the following that although the same broad assumption is made with regard to the work begun or in prospect, it is nowhere assumed that a poor phenotype is necessarily of inferior genetic quality or a good phenotype superior genetically. The point of view is rather that, since detailed trials cannot be made of every parent tree available, attention will naturally be concentrated in the first place on trees of marked phenotypic superiority, growing in conditions which do not suggest that environment is responsible for that superiority. No such tree, however, would be accepted finally without adequate progeny trials.

'In his second chapter, Lindquist argues that in the more thickly populated regions and those where timber cutting has long been a major industry, and especially in the case of Scots Pine and the types of Birch with figured wood, continued selective fellings have had a dysgenic effect: the most valuable timber trees have been felled, inferior ones left, and no attention has been paid to quality of seed-bearers, hence the progressive deterioration in genetic quality. The remedies, and the means of maintaining the highest possible

[1] *Den skogliga rasforskningen och praktiken.* [*Racial research in forestry from the practical point of view.*] Svenska Skogsvårdsföreningens Förlag, Stockholm, 1946, pp. 176 [Sw.]—With numerous photographs, mainly of élite trees and stands.

genetic quality in Swedish forests, are considered in four chapters which form the major part of the book:—

'(1) *Immediate measures*: (*a*) *Silvicultural operations*—Tending operations should remove coarse-branched or slow-growing trees and those showing poor natural pruning; in regeneration fellings the seedbearers left should be of high quality and rate of growth. There is a definite need for propaganda to drive home the idea of genetical selection in such operations. (*b*) *Seed harvesting and the seed trade:* The first requisite is nation-wide mapping of tree populations by trained persons; such a survey was begun for Scots Pine about four years ago, and preliminary maps have already been prepared for Norrland and northern Svealand. As a standard for appraisal was obviously essential, use was made of a classification devised by the Royal Forestry Board and slightly modified in consultation with that body by the private breeding enterprises represented by the author. The main criterion is the frequency in a given population—and it should be remembered here that natural regeneration has been the general rule in Sweden—of markedly superior phenotypes, a high frequency holding out prospects of cheaper and more efficient seed collection, a greater chance of good parentage on the male side, and a greater chance of genetic stability in the superior trees. Stands have been graded as: (i) "*Plus*" *stands*, in which fine-branched, narrow-crowned trees predominate. After removal of the few broad-crowned trees, crown density should be at least 0·6 and the residual stand will constitute what some have called a "living seed store", furnishing *extra prime* seed. (ii) "*Normal*" or "*zero*" *stands*, in which after removal of the inferior trees a light shelterwood of narrow-crowned and intermediate trees should remain. For the time being the bulk of Pine seed requirements ought to be derived from such stands, cone picking to be done from felled trees, especially in the later cuttings, and seed to be graded as *prime* if taken only from the better trees, and as *standard* if no discrimination is exercised. (iii) "*Minus*" *stands*, in which removal of the inferior types would be practically a clear felling. These are usually near settlements and much seed must have been collected from them in the past, but the prevention of seed collection in such areas must be regarded as an essential step in the breeding programme. In the first three years of mapping, under the Society for Practical Forest Tree Breeding and its offshoot *Gävleborg läns skogsträdsförädling*,[1] of Scots Pine in Norrland and Dalecarlia, over 200 "plus" stands totalling some 400 ha. have been recorded, while the "normal" areas appear to constitute about one-half of the forest area. In the county of Gävleborg it was expected that in the coming season about 100 kg. of seed would be got from "plus" stands and 800–1,000 kg. of prime seed from fellings. This would be enough to cover all immediate local requirements. The case of Norway Spruce is rather simpler, as "minus" areas are uncommon and "plus" areas frequent, in some regions occupying greater areas than the "normal" stands. Some form of official seed control is now an urgent need if the use of seed graded in this manner is to develop properly and trade abuses to be prevented. Lindquist suggests that the County Forestry Boards would be the fittest organizations for controlling collection and extraction. (*c*) *Possible*

[1] The Society as a whole was not ready to engage straight away on Jensen's full programme of seed production in special orchards, but a number of members combined for this purpose under the name *Gävleborg läns skogsträdsförädling* [Gävleborg County Tree-Breeding]. These were the County Forestry Board of Gävleborg and the companies—Stora Kopparbergs Bergslags AB, Kopparfors AB, Bergvik and Ala Nya AB, Ljusne-Woxna AB, Iggesunds Bruk, Marma-Långrörs AB and Ströms Bruks AB—who have pressed on with the programme, and under the Gävleborg County Forestry Board have set up a grafting centre at Kratten. Graft plantations are planned on the lands of the member enterprises, and the propagation of élite material is proceeding at Ramlösa, where Holger Jensen is co-operating with the Society.

increases of yield by cautious transfer of climatic races and by roguing of planting stock before it leaves the nursery: Both of these methods appear to hold some promise, and the Society for Practical Forest Tree Breeding has trials in progress.

'(2) *Longer-term measures*: As the long-term research on hybridization, "chromosomal" breeding, etc., is left aside, this chapter—which Lindquist clearly regards as the most essential in the book—is in reality a thorough discussion of artificial seed plantations, perhaps better called seed orchards, as a means of satisfying the expected very large demand for high-grade seed in Sweden. The idea of producing seed in special orchards has been repeatedly urged by Holger Jensen of Ramlösa Nurseries, who is collaborating with the Society and much of whose work has been devoted to showing that abundant, sustained and early flowering can be induced by practices such as strangulation, bark ringing, root pruning and the use of grafts on slow-growing stocks, lines of work which are familiar from the pioneer work of C. Syrach Larsen in Denmark. It has been provisionally estimated that a total seed-orchard area of 1,200 ha. might be able to produce the whole annual requirement (about 60 tons) of conifer seed in Sweden, and for the hardwoods the area required would be much smaller, e.g. for Oak and Birch areas of 15 ha. each could cover the whole requirement.

'The seed orchards would be composed of élite seedling or grafted stock which would be ringed or strangulated to induce flowering. Jensen proposed that in view of the enormous number of grafts needed to establish such plantations, some should be raised from seed furnished by the earliest graftings, but Lindquist believes that it would be necessary to have many more grafted plantations than envisaged by Jensen, even considering the increased costs and labour involved. Production of the grafted stock calls for skill and special knowledge, hence it would be best to concentrate this part of the work at a few central establishments. Facilities for the work exist at Ekebo and its branches at Brunnsberg and Sundmo, and at the Gävleborg County Forestry Board's station at Kratten. When in full production, these will be capable of producing about 30,000 grafts annually, which, especially in view of the present shortage of suitable scions, should suffice for the next five years. Lindquist considers that, if the scions used are derived from élite trees of the provenance zone concerned and of proven quality in progeny trials, seed orchards will represent a breeding method of far greater direct value than the controlled crossings hitherto produced in Swedish tree-breeding institutions. By bringing together 6–10 different élite strains for reciprocal fertilization, in a position relatively free from foreign pollen, the seed obtained should be of very high genetic quality.

'Seed orchards could be established by County Forestry Boards, or even by individual forest owners, but it would be important to have the stock produced centrally under proper supervision; indeed, any seed orchard that produced seed or plants for sale ought to be inspected and approved by some State authority.

'The orchards should be given the best possible site and tending: they should preferably be in a central position, near to some reasonable means of communication, on level, open ground of good quality, isolated so far as possible from pollen of the same species, and in the most favourable climatic conditions possible within the particular provenance zone, in order to obtain a good seed set. Maps are given to show provenance zones, the limits of which were decided with the collaboration of Eneroth, Langlet and Jensen, for Scots Pine and Norway Spruce; for Oak, Beech and Birch, approximately the same divisions might be made as for the latter species.

'In sum, the advantages of seed orchards would be: (*a*) Concentration of seed production on areas convenient for management, with considerable savings of time and money. (*b*) A probability of higher viability and vitality as a result of favourable climatic conditions for

seed setting. (*c*) The readiness with which fertilizer treatments could be applied, if necessary. (*d*) Increased possibilities of controlling seed pests by spraying. (*e*) Continuity of production achieved by induced flowering, giving abundant seed crops at least every other year and thus simplifying the planning of artificial regeneration projects and largely eliminating seed storage for any considerable period.

'The long-term nature of these proposals emphasizes the need for making a start. In the case of the conifers it is estimated that some 15 years must elapse before seed orchards can be established on any large scale, and a further 10 years before they come into full bearing. For the hardwoods the whole period could possibly be reduced to about 10–12 years.

'(3) *The mother trees of the élite seed orchards:* Considering that the quality of Swedish timber will determine its ability to compete in world markets, Lindquist urges the necessity for equal attention to quality and rate of growth in breeding. An essential part of the work of the Society for Practical Forest Tree Breeding and *Gävleborg läns skogsträdsförädling* is the organization of detailed inventories of élite trees over the whole country, as it is among these that the material for longer-term breeding will be sought. The object is to bring a fairly large number of élites into propagation as soon as possible, with subsequent elimination of types which prove unsuitable in progeny trials, so that the programme shall not be paralysed by the time factor. An élite tree must be an extreme "plus-variant" for its kind in both quality and rate of growth. The qualifications for élite status are discussed in detail for all the common Swedish species, and those for Scots Pine are taken in the following as an example.

'A Scots Pine élite tree must show marked superiority in both height and diameter growth over neighbouring comparable trees; in practice it is required to have a volume at least 50 per cent. greater than the average of the three next largest stems in the immediate vicinity. The standard here set is considered largely to dispose of the possibility that the superiority of an élite over its neighbours could be a result of very localized variations in the environment. An élite tree must have a fine-branched crown, and this factor is balanced against rate of growth in the sense that élites are selected only among the narrow-crowned type, but extremely fine-branched crowns are rejected unless they belong to the absolute dominants in the stand. No great attention has so far been paid to natural pruning of the bole, though trees with coarse branches on the bole, or those with a disproportionately long green crown, have been rejected. The upper crown is taken as a good index to quality, on the assumption that, so far as the absolute dominants are concerned, there is a reasonable degree of uniformity in its environment, and a good upper crown with fine, regular branching probably indicates a good genotype. There is little evidence that heartwood formation is subject to genetic variation, but it has been thought prudent to reject trees poor in this respect. Finally, and especially as the narrow-crowned Pines are on the whole less abundant seed-yielders than the broad-crowned, it is very important not to select against fertility, and an élite must set seed regularly and abundantly.

'In the inventories under the author's guidance, about 3,000 élite Scots Pines have been registered, seed has been collected, and after about 2–3 years of progeny trials some 10 per cent. of the trees have been selected for further detailed examination, while about 100 trees have given such excellent seedlings, and have themselves shown such striking growth that they have been taken up for grafting and mass propagation.

'Among the remaining species discussed, Birch (mainly *Betula verrucosa*) presents special complications owing to the necessity of distinguishing and assessing the timber quality of at least three kinds of figured wood and two of plain wood. A good deal of space is given up to the (rather unreliable) external features, wood characters, distribution and

qualifications for élite status, in the various forms. Further, as triploid hybrids of *B. pubescens* × *verrucosa* are largely sterile, élite material will have to undergo cytological examination and viability and survival tests.

'The progeny trials to which élite trees will be subjected are severe. They must last at least 30–40 years, must be replicated on plots sufficiently large (not less than ¼ ha.) to give reliable indications of yield by area, and must take account of habit, rate of growth, timber characters, hardiness, etc. Since such detailed trials cannot be made for all the élites recorded, trees whose progeny soon shows undesirable characters are rejected at an early stage. In the preliminary grading of élite trees as parents for such seed orchards, the choice falls among rapid growing trees whose offspring have shown particularly good growth in the nursery and which have given scions of exceptional growth in comparative grafting trials.

'A final note on the maintenance of élite trees and "plus" stands for future propagation emphasizes that their quality renders them specially liable to exploitation, and steps must often be taken to ensure that they are not prematurely felled. The Society for Practical Forest Tree Breeding and *Gävleborg läns skogsträdsförädling* have bought up particularly valuable élite trees and the right to pick cones in élite stands. Once a tree has been successfully propagated by grafting, the risk of losing a good genotype largely disappears, and Lindquist suggests that a permanent State arboretum should be formed of grafts of all the most valuable élite trees in Sweden. As the breeding programmes get under way, it may also be necessary to provide for possible switches in future requirements by protecting certain areas as reserves of genetic variation, where the original populations would be allowed to continue without selection.

'(4) *Present employment of the élite material:* Under existing conditions economy must be exercised in the use of élite seed, and direct sowing will be out of the question for the present. Until the élite material becomes abundant and cheap, plantations will no doubt be confined to the best sites as regards both quality class and facilities for extraction; but later, when costs fall, the emphasis will presumably change to the use on the poorer sites of material which will give an increased value yield and possibly even enable improvements to be undertaken. The principle of the right species in the right habitat is obviously more important than ever when élite stock is being used.

'Most of the remainder of the work is devoted to an attempt at assessing in broad terms the influence of the breeding programme on forest practice in Sweden, with chief reference to tending operations in existing forests, the use of high-quality seedbearers for natural regeneration, a consideration of the improvements to be expected from the current use of high-grade seed and the future use of top-grade seed from the special orchards, and the question of silvicultural costs. As regards the last-named it is suggested that the new selections will enable wider spacings[1] to be used, will give less risk of failure, more continuous growth during the period of closure (and therefore less costly cleanings), and entail less selection during thinnings. These benefits would be most marked in the case of Scots Pine.

'Seed and plant costs for material derived from "plus" stands are bound to be rather high at first, though Lindquist believes on the basis of some provisional estimates that they will be far from prohibitive, especially considering the expected gains in quality and growth. Collection of seed from individual élite trees is naturally undertaken mainly for scientific

[1] In another connexion the possibility is noted of using denser stands of the narrow-crowned types of Scots Pine: many reports suggest that 'plus' stands of this species carry a high stocking for their quality class as assessed from individual increment, and have a strikingly high volume yield per unit area. The matter requires proper investigation.

purposes, though in particularly favourable circumstances, or with an abundant seeder such as Birch, it could pay its way. Jensen's tentative calculations of the cost of seed produced in the future élite seed orchards is also reproduced. Policy is to keep the prices of high-grade seed as low as possible in the national interest, and if the County Forestry Boards become the main producers of seed, this should be possible. When the seed orchards are in full production, conifer seed should become cheap enough for use in direct sowings, and élite seed of Birch and Oak might be even cheaper than the ordinary seed at present on the market.

'The two brief concluding chapters contain speculations on the national consequences of using high-quality, high-yielding stock and an outline of the organizations in Sweden now interested in tree breeding.

P. G. B.'

[2293]. 12.11.3:12.25–9. Darlington, C. D., and Janaki, E. K. *Chromosome Atlas of Cultivated Plants.* George Unwin and Son, Ltd., London. 1945. pp. 397.

After an introductory essay of some 40 pages on the origin of cultivated plants and the use and meaning of chromosome numbers, there follows the 'atlas', i.e. tabulated information on vernacular names, chromosome numbers, author (of chromosome count), use and distribution of more than 11,000 species of plants belonging to 2,000 genera arranged by families. Genera in which apomixis is known are noted, since its occurrence is usually related to ploidy. Cultivated forms are distinguished from wild species. The bibliography contains about 1,400 references.

[2361]. 21.0 (45):11:12.19. Pavari, A., and Philippis, A. de. *La sperimentazione di specie forestali esotiche in Italia. Resultati del primo ventennio.* [*Experiments with exotic forest species in Italy. Results of the first twenty years.*] *Ann. Sper. agr.* 38, 1941. pp. 648+ plates+maps. [It.]

This large and comprehensive work consists of three parts: (1) a general account of the introduction of exotic species into Italy, the experiments on which the work is based, and the relevant ecological conditions in Italy (67 pages); (2) detailed descriptions of the principal exotic species, with notes on experiments in growing them in Italy and elsewhere in southern Europe (526 pages); (3) the authors' conclusions and recommendations of the most suitable species for planting in Italy. There is a bibliography of 16 pages and maps of Italy showing climatic-forest zones, vegetation, rainfall, &c.

[2817]. 7:02.1:6 (43). Dieterich, V. *Forstliche Betriebswirtschaftslehre:* Bd. I. *Die wissenschaftliche Grundlegung.* [*Theory of the Economics of Forest Management:* Vol. I. *The Scientific Basis.*] Verlag von Paul Parey, Berlin. 2nd (revised) ed., 1943. pp. 433. [G.] [Univ. of Munich.]

The first edition of this work was reviewed in *For. Abstr.* 1 (205). No occasion has been found for any major alteration, and the present edition differs only in having been brought up to date in some details and revised as to style, and in the addition of a short section, under Costs, on Interest on Debts, Apanages, and Landlord's Liabilities.

[2831]. 90 (73):07.1:07.2:09.7. United States. *Problems and Progress of Forestry in the United States.* Report of the joint committee of forestry of the National Research Council and the Society of American Foresters. Society of American Foresters, 825 Mills Building, Washington, D.C. 1947. pp. v.+112. Price $1.75.

The joint committee was set up in 1942 in order to study the present forest situation in the United States, to review what is being done in various fields of forestry, and to determine

and interpret problems that are not already being studied by existing agencies. The report is made up as follows: Part I reviews the present state of forests, forestry, and wood utilization in the United States; Part II, public responsibilities and action in forestry; Part III, problems of private forestry; Part IV, public action in advancing private forestry; Part V, education and research in forestry. Special emphasis is directed to the urgent need for further research into the specific characteristics and properties of second-growth wood of various species and to the need for modification of existing utilization practices in order to use low-grade wood more effectively. The committee urges that silvicultural research should further stress the importance of information on quality of wood produced under different growth conditions, with special emphasis on the significance of production of timber suited to industrial use. It is also recommended that the extent of overgrazing of forest and open range lands in National Forests should be determined by a special outside commission of experts. The Joint Committee strongly recommends that, in the event of further organization of federal departments and bureaux, the Forest Service should be retained in the Department of Agriculture. It is recommended that federal and state support be provided on a larger scale than at present to reduce the fire hazard to a point where it will not discourage private owners from adopting constructive measures of forestry. In view of the inevitably slow progress in enactment of uniform legislation regulating cuttings on private lands in the large number of states in which forests are important, the committee recommend that Congress provide authority for federal regulation of private forests, adequately supported by funds for administration of the law.

[2846]. 95.3. Köstler, J. *Das forstliche Kreditwesen.* [*Forestry Credit.*] *Silvae Orbis*, No. 10, 1943. pp. 80. [G.g.]

A preliminary digest of material from a number of countries, gathered in pursuance of a resolution at the second International Forestry Congress, Budapest, 1936, by the International Institute of Agriculture and later by the Centre International de Sylviculture. The chapter headings are: peculiarities of forestry credit; significance of various types of credit; substitute arrangements; special laws on forestry credit; future tasks in connexion with credit in forestry.

The material collected was heterogeneous and incomplete, so that no complete review of actually existing mortgage conditions was possible, though there were some indications that certain types of forestry credit are probably worth encouraging in future. The best conditions for the development of forestry credit are afforded by a forest policy directed towards sustained yield, together with the creation of forestry enterprises that are soundly managed as businesses.

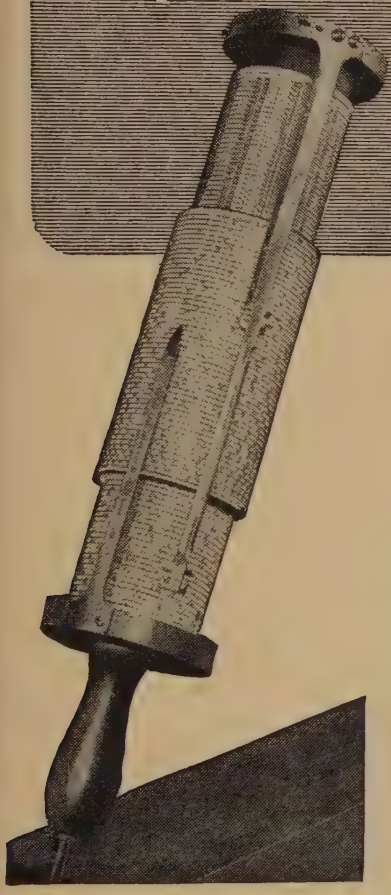
[2850]. 97.1. Graham, E. H. *Natural Principles of Land Use.* Oxford University Press, New York, Inc. 1944. pp. xiii+274. Price $3.50.

This book is composed on the premise that biological concepts can contribute importantly to the wise use and management of land; it treats significant natural phenomena so that they provide guiding rules of thumb for the land manager.

A general ecological survey discusses the distribution of plant and animal communities, plant succession and indicators, food-chains, range and territory, cycles, methods of studying populations and classifying land, &c. Land use is dealt with in sections on farms, forests, grazing, wild life, waters, and human welfare. The illustrations, all photographs, contain a large number of 'before-and-after' examples. In discussing forests, reference is made to shifting cultivation (here called bush fallowing) in New Guinea, Tanganyika, and

Guatemala, old-field succession in New England and the North-west, the effect of game and grazing, of rodents and mammal-insect relationships in U.S.A. Some features of the introduction of exotics are illustrated by the Lantana-bird-armyworm cycle in Hawaii, the suitability of strains of Douglas Fir for Europe, the biological control of prickly pear, and the use of climographs as indices of regional suitability.

SURVEYING & DRAWING EQUIPMENT OF QUALITY WHICH ENSURES ACCURACY



THE FULLER CALCULATOR

For multiplication — division — proportion percentages—Logs—Roots

ACCURACY 1-10,000

Does the work of a calculating machine at a fraction of the cost

Theodolites, Levels, Planimeters, Drawing Instruments, Drafting Machines—in fact, everything which the Draughtsman and Surveyor require for precision work—are included in the Stanley range. Each instrument has the highest standards of Accuracy, Quality and Finish.

(Write for descriptive leaflets F. XXI)

STANLEY

REGISTERED TRADE MARK

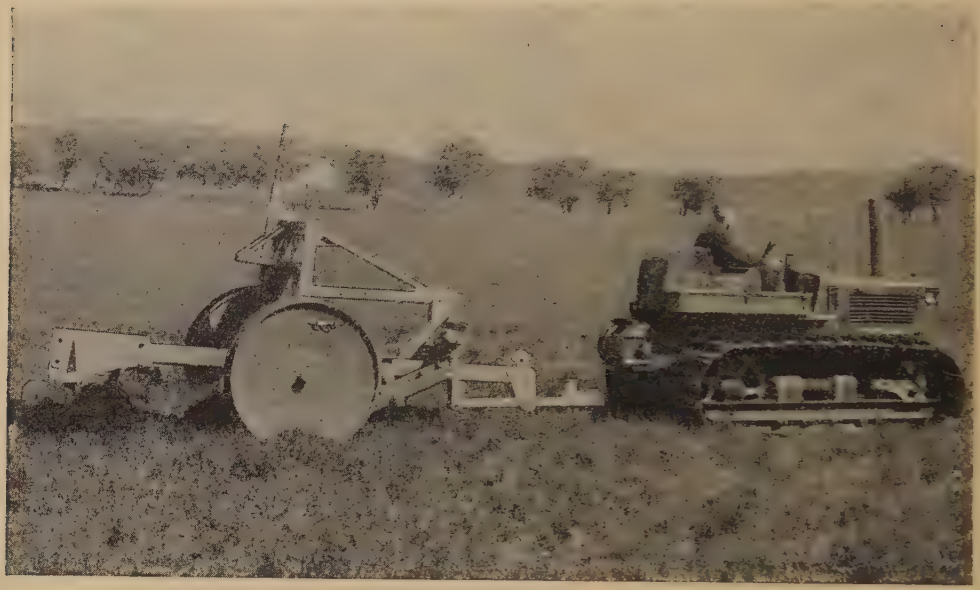
W. F. STANLEY & CO., LIMITED

NEW ELTHAM · LONDON · S.E.9

TELEPHONE : ELTHAM 3836

[1 *end*]

THE CUTHBERTSON DRAINAGE MACHINE



AND ITS JOB

Irrigation

Drainage

Pipe Lines

Cable Laying

Afforestation

Sugar Cane and Sisal

Plantations

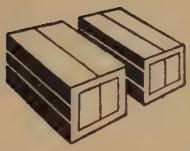
Patented, Designed, and Manufactured by

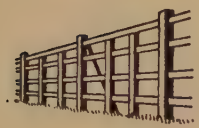
JAMES A. CUTHBERTSON, Limited

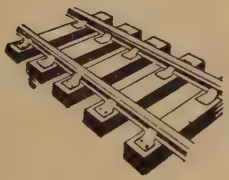
Agricultural and General Engineers

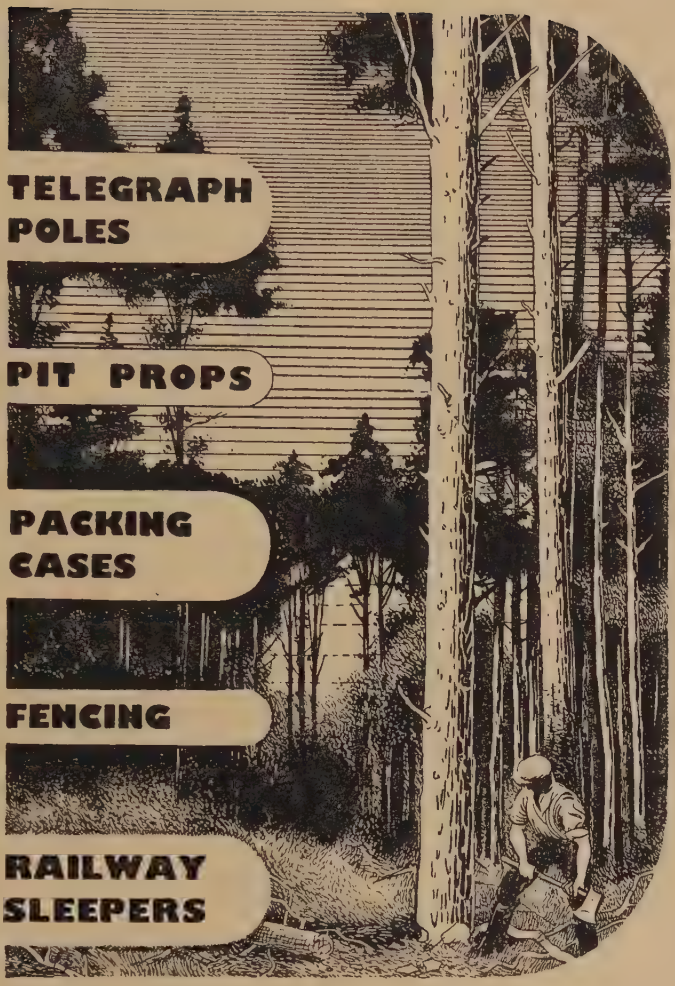
BIGGAR, Scotland

Phone: BIGGAR 20









We have specialized in the supply of home grown and imported timber for this type of work for 122 years

A. & G. PATERSON LTD.

ST ROLLOX SAWMILLS & BOXWORKS

60-80 TENNENT ST., GLASGOW, C.4

Telephone BELL 3236 (3 lines)

Permanent Sawmills at Banchory & Aberdeen

Forest Sawmills throughout the Country

THE IMPERIAL FORESTRY BUREAU
OXFORD, ENGLAND

This branch of the Imperial Agricultural Bureaux, set up by the Governments of the British Commonwealth, operates as a centre for the collection and dissemination of information on forestry, particularly on forest policy, silviculture, management, protection, forest products, utilization, and sciences allied to forestry.

Forestry Abstracts

A survey of the current world literature on forestry; each issue normally includes a review of the literature on some particular subject. It is issued quarterly for an annual subscription of 25*s.* with a reduction of 20 per cent. for orders received direct from residents of the British Commonwealth. Prices include postage and are payable in sterling.

Forest Products and Utilization

Abstracts of the world's current literature of interest to the timber trade and to industries using wood and its by-products, or oils, gums, resin, rubber, fibres and other forest products, covering also logging, conversion, seasoning, constructional engineering, manufacturing processes, supplies and sources, analyses, patents, &c., together with occasional reviews of current progress on applied research. It is issued quarterly for an annual subscription of 10*s.* Prices include postage and are payable in sterling.

Technical Communications

1. 'Gas Producers for Motor Vehicles and their Operation with Forest Fuels' (3*s.*); 2. 'Co-operation in Forestry' (4*s.*); 3. 'Forestry Credit' (2*s.* 6*d.*); 4. 'The Application of Meteorology to Forest Fire Protection' (2*s.* 6*d.*); 5. 'Management in Selection Forest, with particular reference to the application of the "méthode du contrôle" in Switzerland' (3*s.*).

Publications in collaboration with other Bureaux

'Forest Tree Breeding and Genetics' (5*s.*); 'The Use of Aerial Survey in Forestry and Agriculture' (7*s.* 6*d.*); 'The Use and Misuse of Shrubs and Trees as Fodder' (9*s.*).

All correspondence regarding these publications may be addressed in the first instance to:

IMPERIAL AGRICULTURAL BUREAUX, CENTRAL SALES BRANCH
PENGLAIS, ABERYSTWYTH, GREAT BRITAIN

FORESTRY COMMISSION PUBLICATIONS

The following may be obtained from H.M. Stationery Office, York House, Kingsway, London, W.C. 2, or through any Bookseller.

GENERAL REPORTS

	Price s.	d.	*Plus Postage* s.	d.
Report by the Commissioners on Post-War Forestry Policy, 1943	2	0	2	2
Supplementary Report, 1 (Private Woodlands)		2		3
Or the two Reports	2	2	2	4
Annual Report, for the year ended 30 September, 1945		9		11

BULLETINS

No. 8. British Bark Beetles	3	6	3	8
No. 13. Studies on Tree Roots	3	6	3	8
No. 14. Forestry Practice (revised 1946)	2	0	2	2
No. 16. Studies on the Pine Shoot Moth	1	0	1	2
No. 17. Cultivation of the Cricket Bat Willow	2	0	2	2
No. 18. Spring Frosts	2	6	2	8

OTHER PUBLICATIONS

The Thinning of Plantations		9		10
Establishment of Hardwoods (1947)		9		10
Forestry as a Career (revised 1947)		3		4
Forestry Commission Yield Tables		6		7
Woodland Mosses (1947)	2	0	2	2
Argyll National Forest Park Guide (revised 1947)	1	6	1	8

PRICED LEAFLETS

2*d.* each, plus postage 3*d.*

4. The Black Pine Beetle; 7. Adelges attacking Spruce; 12. Income Tax and Death Duties on Woodlands; 19. Elm Disease; 23. Pit Props.

UNPRICED LEAFLETS

The following are obtainable free of charge, whilst stocks permit, on application to the Secretary, Forestry Commission, 25 Savile Row, London, W. 1:

2. Adelges Cooleyi on Douglas Fir; 5. Conifer Heart Rot; 6. Honey Fungus; 9. Forest Fires; 14. The Phomopsis Disease of Conifers; 16. Two Leaf Cast Diseases of Douglas Fir; 17. Chafer Beetles; 20. Watermark Disease of the Cricket Bat Willow; 21. Leaf Cast of Larch; 24. Explanatory Note on the Dedication of Private Woodlands; 25. Replanting of Felled Coniferous Woodlands in Relation to Insect Pests.

FOREST TREES

Including Conifers and Hardwoods, Seedlings and Transplants, also Hedging Plants and Trees suitable for shelter belts

Special carriage paid quotations on request

Please write for AUTUMN LIST in September
TREE SEED LIST in February

All requirements supplied for the Private Estate Nursery, including Transplanting Boards for lining out seedlings

We are buyers of cones at current market Prices. We are especially anxious to obtain seed from races of trees of the most suitable type, and would appreciate the co-operation of Owners in helping us to secure such seeds by supplying us with the cones. This would be in the interests not only of ourselves and private planters but of good forestry practice

BENJAMIN REID & CO.

Forest Tree Growers

20 HADDEN STREET, ABERDEEN

'Phone :
Office 2335. Nursery 2024

Telegrams :
'Reid, Aberdeen'

CO-OPERATIVE FORESTRY SOCIETY (SCOTLAND) LTD.

¶ Founded in 1911 this non-profit Society provides members with advice and practical help on all forestry problems.

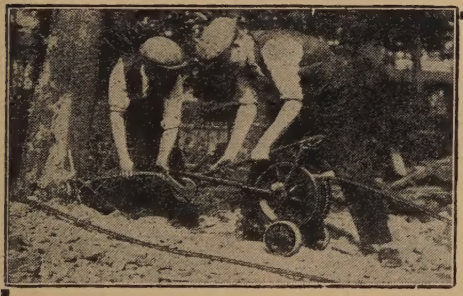
¶ Members obtain discounts on all purchases by bulk buying. Plants, netting, tools, seeds, fertilisers, chemicals, and machinery are available.

¶ Subscriptions are from 10*s.* to £2 a year.

President:
Sir SAMUEL STRANG STEEL, Bt.

Forest Officer:
BRUCE URQUHART, B.A. (For.) Oxon., F.L.S.

26 RUTLAND SQUARE, EDINBURGH



The procedure is to anchor the winch as shown above. The power is applied by moving a steel lever, and a stout steel cable transmits the pull (anything up to 24 tons) to the tree being pulled. A practical machine. Used on the royal estates both at Windsor and Balmoral.

Write for Illustrated Catalogue

TREWHELLA BROS.
Pty., Ltd.
ROLFE STREET, SMETHWICK
BIRMINGHAM

MONKEY WINCH
Tree and Stump Puller

Stub felling trees becomes a different proposition altogether with this machine. The same men, but only a small fraction of the time, and all the roots come out with the tree. Invaluable for getting dangerous trees, and those overhanging roads and buildings.

SADDLERY AND HARNESS

FOR

AGRICULTURE, TIMBER PRODUCTION
TIMBER HAULAGE CONTRACTORS
DEER FORESTS AND GROUSE MOORS

For Forestry Work we make a Special Pack Saddle fitted with carrying irons and straps, as supplied to The Forestry Commission, Scotland

Makers of Saddlery and Harness
for 125 years

JAMES FRASER

10 HIGH STREET, DINGWALL

Telephone 2181

THOMSON'S HOTEL

26/27 DRUMSHEUGH GARDENS, EDINBURGH

'Phone 22395

Position central yet quiet. Elevator and all up-to-date equipment

Excellent cuisine—reasonable rates

The Hotel adjoins Forestry Commission (Scotland) Headquarters

EVERYTHING SCIENTIFIC

PHOTOGRAPHIC REQUISITES APPARATUS FOR RESEARCH RADIO

ANDREW H. BAIRD

33/39 Lothian Street, Edinburgh (between Old and New University Buildings)

CONTENTS

British Forestry. By LORD ROBINSON 1

Co-operative Forestry in Britain. By BRUCE URQUHART 6

Forestry in the Netherlands and the State Forest Service. With plates I, II. By J. A. VAN STEIJN 14

The Bowmont Norway Spruce Sample Plots (1930–45) (*Picea abies* Karst. syn. *P. excelsa* Link). With plates III, IV. By F. C. HUMMEL . . 30

The Strength of Home-Grown Timber Pit-Props. With plates V, VI. By F. H. ARMSTRONG 41

Utilization of Home-Grown Larch in Great Britain (*Larix decidua* Mill. syn. *L. europaea* DC.). With plate VII. By JOHN T. SMITH . . 77

The Fine Structure of the Fibres of Normal and Tension Wood in Beech (*Fagus sylvatica* L.) as revealed by X-Rays. With plate VIII. By R. D. PRESTON and V. RANGANATHAN 92

Bats. By J. M. D. MACKENZIE 99

Society's and Other News 108

REVIEWS

Longleaf Pine (W. G. WAHLENBERG). By W. M. MCNEILL 110

Forest Soils (H. J. LUTZ and R. F. CHANDLER). By H. M. STEVEN . . 111

Soil Fertility, Renewal and Preservation (E. PFEIFFER). By G. K. FRASER . 112

Forestry and Woodland Life (H. L. EDLIN). By M. L. ANDERSON . . 115

Our Forests (W. H. ROWE). By J. ALAN B. MACDONALD 117

Forestry and Forest Products: World Situation 1937–46 (Food and Agriculture Organization of the United Nations, dated 15th August, 1946). By THE EDITOR 119

NOTICES

Forestry. (Young Farmers' Club Booklet No. 20.) By H. L. EDLIN . . 124

Knot-free Red Pine by De-budding. By A. BICKERSTAFF . . . 124

Fire Control Notes, Vol. 7, No. 3, Vol. 8, Nos. 2 and 3. (Forest Service, U.S. Dept. of Agriculture, Washington.) 125

Extracts from *Science*, *Forestry Abstracts*, &c. 126

Printed in Great Britain at the University Press, Oxford, by Charles Batey, Printer to the University